THE ENGINEER

FEBRUARY 12, 1954

Britain's First "Breeder" Pile in Operation at Harwell

THE Department of Atomic Energy states that "Zephyr," the zero-energy fast reactor designed and built at Harwell became critical for the first time on February 5th. It may be recalled that "Zephyr" is intended to be used for gaining operational experience with a fast reactor and for obtaining information about control systems, nuclear constants and materials and methods of nuclear construction—information of the kind that can only be derived from practical experience. It is designated a zero-energy reactor because it will not generate any useful power : the dissipation will be of the order of a few watts, the pile will not become highly radioactive and will not require cooling and it should therefore be comparatively simple to make modifications to the reactor as required by experience. The reactor "Zephyr" consists essentially of a small core of plutonium enclosed in a metal can. This core, which in the case of "Zephyr" is only of the order of half a cubic foot in capacity, is surrounded by a comparatively massive blanket of uranium, which either reflects any neutrons escaping from the core or absorbs them and thereby produces more plutonium. The practical experience gained from "Zephyr" will be applied in the design of an experimental power-producing fast reactor which is being produced jointly by the establishments at Harwell and Risley.

Brancker Memorial Lecture

LAST Monday, the twelfth Brancker Memorial Lecture entitled "The Impact of the Gas Turbine on Civil Aviation," was read by Sir Miles Thomas before the Institute of Transport in London. Much of this lecture was devoted to the philosophy adopted in this country towards the application of both the turbo-jet and the turbo-propeller engine to civil aircraft, and of the lessons which have been learned so far in operating the "Comet." Sir Miles emphasised the importance of saving time on the ground, which was so much more important when operating jet aircraft and he referred to the pioneering work that had been undertaken by B.O.A.C. in this sphere. In referring to engine economics he stated that with gas turbines costing up to £40,000 each, it was particularly necessary that a greater output per unit cost must be achieved and that the "hot" parts of engines be salvaged and reworked. It might well be, he stated, that just as some road operators bought tyres on a mileage basis, so airline operators might buy engines in terms of flying hours, the manufacturer backing his product financially throughout its life. Sir Miles then made a plea for greater production. He said that "To-day, our call is for production, not merely prototypes. Too much talk of jam to-morrow leads to nausea to-day. The war has been over eight years ; airlines fly across the Atlantic nearly 100 services a week. There is still no commercial British aircraft that will fly the Atlantic competitively and profitably. That is a sobering thought. Before we search for the secrets of supersonic civil aircraft, before we dream of shadowy space-ships and week-end excursions to Venus or any other planet, let us get down to the humdrum but surely satisfying task of making quickly in quantity and selling quickly in quantity the substance that is within our grasp. On the manufacturing side, for the good of our prestige and our pockets, let us have fewer prototypes and more production." In a brief comment upon the flying-boat, Sir Miles said that he himself was an ardent addict of flying-boats but at the moment all projected aircraft could fit into the current airport pattern. That made the way of the flying-boat pioneer extremely hard commercially, because it meant that the first operator would bear the whole cost of the ground-based equipment and someone would also have to pay for the specialised customs facilities, refuelling, passenger handling and other facilities involved. Speaking of future engine development, Sir Miles mentioned the advantages of external pod mounted engines and thought this American principle might prove to be the right one.

Launch of Oil Tanker "World Glory"

DURING the post-war years large numbers of oil tankers of increasing capacity have been built, and on Tuesday of this week the largest vessel of this class was launched from the Quincy yard of the Bethlehem Steel Company, at Quincy, Massachussets, U.S.A. The ship is building for World Tankers Corporation and was ordered by Mr. Stavros S. Niarchos as part of an independent fleet of tankers which now approximately totals 1,250,000 tons deadweight. This latest addition to the fleet has a length overall of 736ft 6in, a length between perpendiculars of 705ft by 102ft moulded breadth and 50ft moulded depth. On an estimated load draught of 37ft 6½in the displacement is expected to be 58,300 tons and the corresponding deadweight is given as 45,100 tons, associated with a loaded service speed of 16 knots. Propulsion of the ship is by a single set of geared turbines, consisting of h.p. and l.p. units capable of developing a maximum of 15,000 s.h.p. at 100 r.p.m., and a service power of 13,600 s.h.p. at 97 r.p.m. of the propeller, which is of five-bladed design and has a diameter of 22ft 6in, a pitch of 17ft 4in and a surface area of 232 square feet. Steam is supplied by two boilers at a pressure of 600 lb per square inch and a temperature of 850 deg. Fah. Electrical power for the various auxiliaries is provided by two 500kW turbine-driven generators and one 75kW diesel-driven generator, while for handling the cargo oil the ship is equipped with four single stage, double-acting, horizontal centrifugal pumps, each having a capacity of 3500 gallons per minute. Fresh water is provided by two distilling plants which are each capable of producing 10,000 gallons every twenty-four hours.

Diesel Passenger Trains on British Railways

PLANS to extend the use of multiple-unit, lightweight diesel trains on British Railways have been announced by the British Transport Commission. In addition to the West Riding of Yorkshire and West Cumberland schemes already announced, it has now been decided to provide similar services as soon as possible in Lincolnshire, in East Anglia, between Newcastle and Middlesbrough, and between Edinburgh and Glasgow. Each of these four schemes will partly substitute and partly supplement existing steam services. The greater economy and flexibility of the diesel railcars on selected routes is expected not only to enable existing steam services to be worked at lower cost, but also to provide better facilities which will create fresh business. The total expenditure which has been approved on this form of development on British Railways now amounts to over £2,000,000. Eight two-car units for the West Riding, thirteen for West Cumberland and thirteen for Lincolnshire are at present being built at Derby Works. Production arrangements for thirteen two-car units for East Anglia, ten motor vehicles and ten trailers for the Newcastle–Middlesbrough services, and six multiple-unit train sets and eight spare vehicles for the Edinburgh-Glasgow services are now being worked out. Similar trains will be used for all areas, except Edinburgh–Glasgow. They will consist of two coaches, one powered by two underfloor engines of at least 125 h.p. each, the other being a trailer or another motor coach as required. Each two-car unit will have a driver's cab at each end, and seat about 130 passengers. If required, the two-car units will be formed into multiple-coach trains to suit traffic requirements.

National Power Farming Conference

THE fourth national power farming conference began at Cheltenham on Tuesday afternoon, the opening address being given by Dr. John Renny, director of the Agricultural Engineers' Association. In the course of it, Dr. Renny commented upon the growth of this country's agricultural engineering industry during and since the war, recalling that between 1938 and 1952 the value of its annual output had increased from £4,500,000 to £106 million. It should also be borne in mind, Dr. Renny said, that whilst in 1938 this country's exports of tractors and agricultural machinery were valued at £1,300,000, in 1952 sales to overseas markets reached a total of £62,000,000. The British farmer, Dr. Renny continued, must equip himself to reduce cost, and if he did so, no farmer need fear going forward towards an increased production. Such an expansion of farm production gave the agricultural engineer a sound and satisfactory home market, and with that home market as his main basis, he had the necessary economic support for meeting the ever-increasing competition abroad. The two markets, home and export, Dr. Renny suggested, rendered possible a production programme of such magnitude as would lead to better-designed machines at lower prices for use both at home and overseas. Finally, Dr. Renny referred to the close collaboration which must continue between the farmer and the manufacturer and distributor of agricultural machinery. Each of them, he said, had an essential contribution to make to the expansion of power farming.

Air Traffic in 1953

THE Ministry of Transport and Civil Aviation has now published details of air activity at aerodromes in the United Kingdom and the Channel Isles for last year. It is shown that in 1953 United Kingdom airports handled over 3,500,000 passengers, of whom over half used London Airport and Northolt. This was an increase of 24 per cent compared with 1952, whereas the increase in 1952 over 1951 was only 13 per cent. Possible causes of this accelerated growth in traffic include the Coronation, introduction of cheaper fares (particularly tourist rates on European routes), new types of aircraft (e.g. "Viscount"), and the relaxation of currency restrictions. London Airport, with 1,205,000 passengers, showed an increase of 40 per cent on the previous year, whilst Northolt handled 723,000 passengers, which represents a decrease of 7 per cent. Outside the London area Renfrew handled the most passengers with a total of 210,000, an increase of 34 per cent. Next in order was Ringway, with 209,000 (30 per cent increase) ; Prestwick, with 187,000 (11 per cent increase) ; Nutts Corner, with 167,000 (13 per cent increase), and Ronaldsway, with 148,000 (17 per cent increase). Other airports at which passenger traffic increased considerably over 1952 were Lympne, 84,700 (206 per cent increase) ; Southampton, 78,300 (31 per cent increase) ; Birmingham, 66,000 (42 per cent increase), and Stansted, 53,900 (395 per cent increase). Altogether, the provincial aerodromes handled 1,600,000 passengers. In the Channel Islands, Jersey Airport had 293,000 passengers (16 per cent increase) and Guernsey 127,000 (9 per cent increase). London Airport increased its freight handling by 12 per cent to 17,140 short tons.

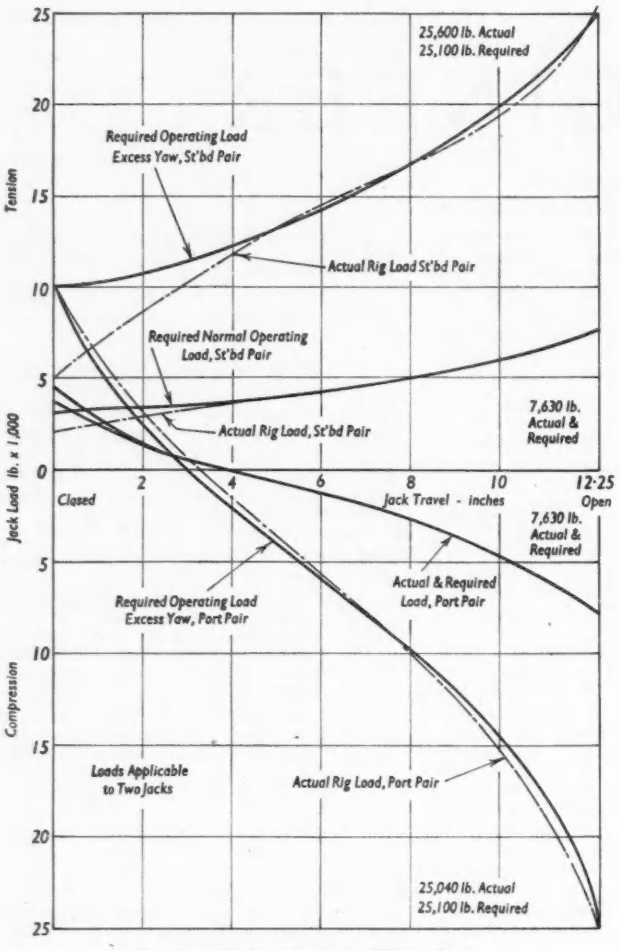
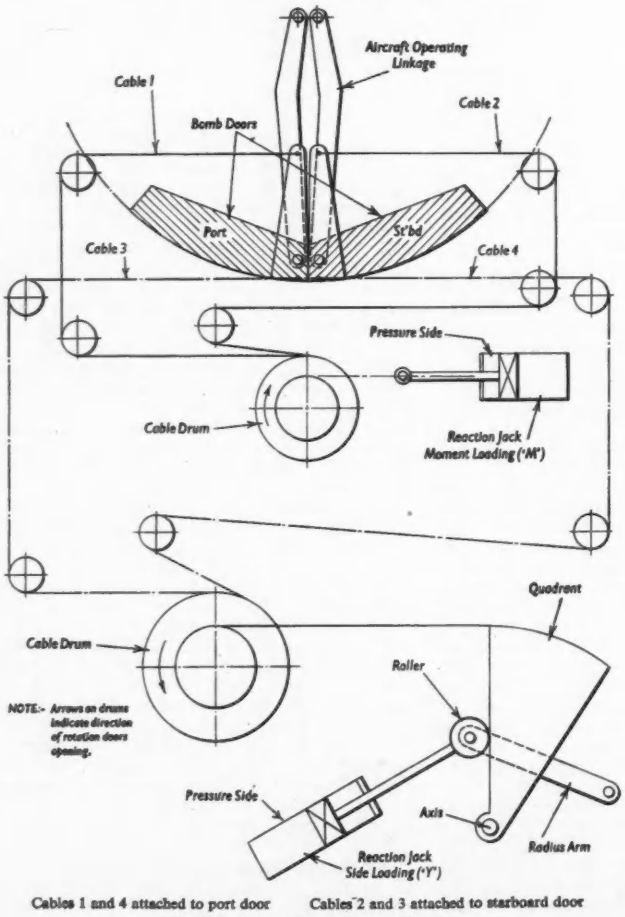


Fig. 22—Reaction Jack Load-Travel Curves



Cables 1 and 4 attached to port door Cables 2 and 3 attached to starboard door

Fig. 23—Front End Loading Diagram

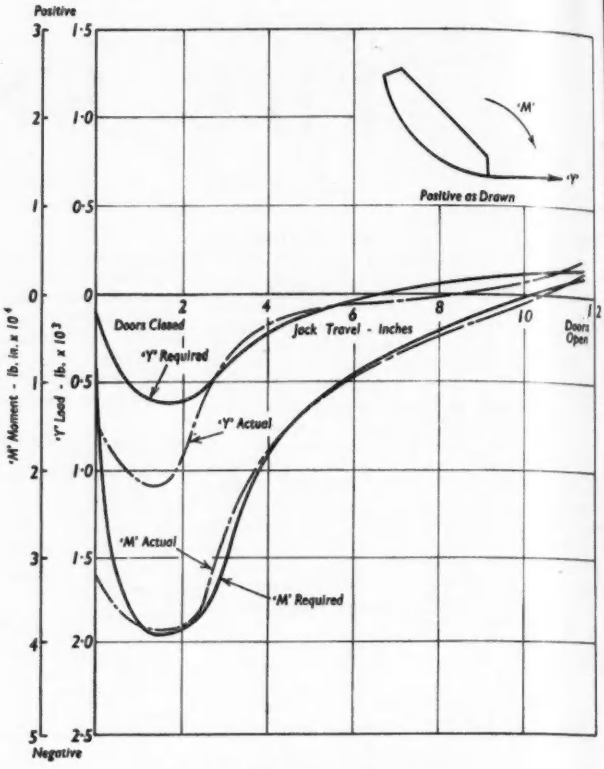
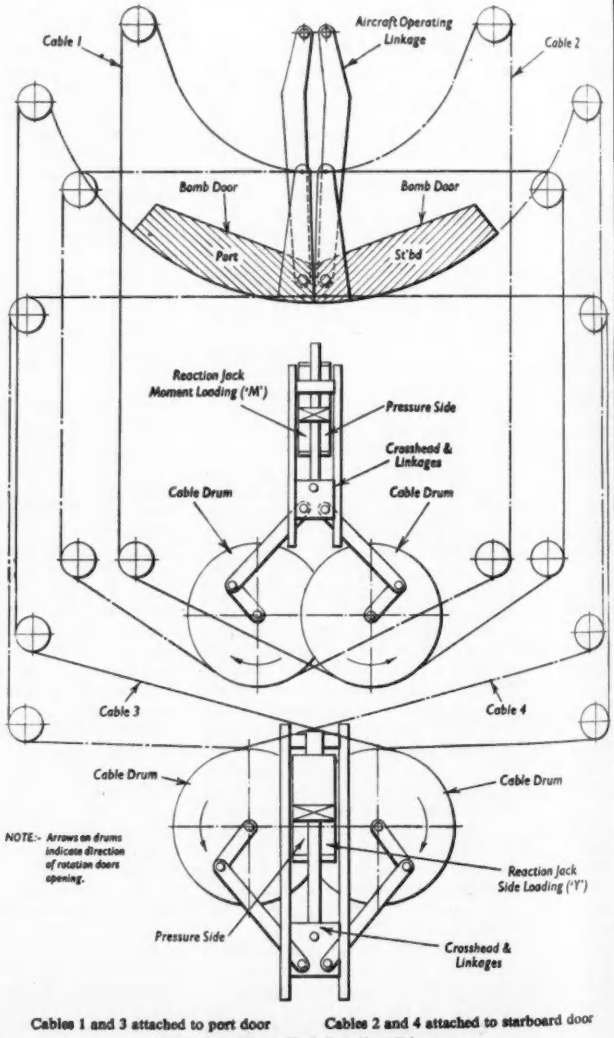


Fig. 24—Front End Loading Curves



Cables 1 and 3 attached to port door Cables 2 and 4 attached to starboard door

Fig. 25—Rear End Loading Diagram

Aircraft Hydraulic Test Rigs

By R. T. SEWELL*

No. III—(*Concluded from page 215, February 5th*)

The increased complexity of high-pressure hydraulic systems for modern aircraft has resulted in a new approach to the problems of testing. The method of test and the design and use of test rigs is discussed, with particular emphasis on the necessity of testing complete systems under fully representative conditions.

Jack Loading Systems

THERE are various methods of applying loads to hydraulic jacks operating control surfaces, some of which are as follows :—

Constant Load System.—This system uses relief valves in combination with a reaction jack, see Fig. 26.

The system is maintained hydraulically full by the pistonless accumulator, which is inflated to a low pressure (20 lb per square inch). As the aircraft jack extends, oil is displaced from the annular side of the reaction jack through relief valve *A* set to blow off at a pressure necessary to give the required load. The oil then passes round the reaction circuit and back into the full-area side of the reaction jack. On aircraft jack closure, oil is similarly displaced from the full-area side of the reaction jack through relief valve *B*.

The difference between full and annular volumes is taken up by the accumulator. Free return flow is ensured by the non-return valves. The setting of the relief valves is

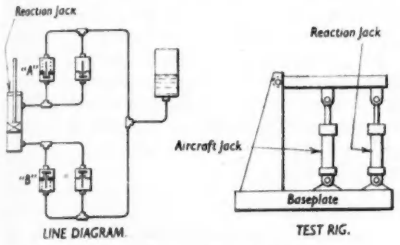


Fig. 26—Constant Load System

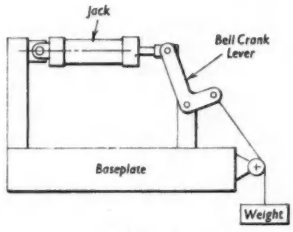
calculated, and in practice the valves are set below the theoretical value as allowances must be made for the pressure rise due to flow through the valves.

This reaction system is a simple method used more for endurance testing of jacks than simulation of loads occurring in flight. It will be seen from the diagram that the reaction always opposes the motion of the aircraft jack, no matter in which direction it moves, and that the reaction is of constant value throughout jack travel. Such a condition of loading seldom arises on an aircraft, the most common loading is one where the jack moves in one direction against a resistance, and is assisted by the external load during the return stroke (or vice versa). However, the constant load system may be used where it is considered that the service is relatively unimportant as regards simulation of loads.

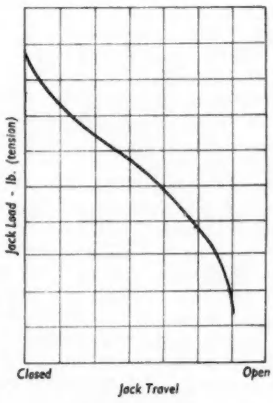
Deadweight System.—It is sometimes a temptation to use this system by reason of its cheapness and relative simplicity. However, the maximum practicable deadweight is about 1000 lb, and this places a severe limitation on the use of the system, as many aircraft jacks are required to operate against loads of 30,000 lb or more. It can be used on services with small loads and comparatively slow operating times, but careful consideration must be given to the inertia effects produced by the deadweights. There is a very real danger in trying to simulate aerodynamic loads with deadweights if the service has a rapid operating time, as the rig is liable to break and everything may go through the floor.

The linkage between the aircraft jack and the deadweight is by a suitable combination of cranks and cables passing over pulleys. The design of suitable geometry to reproduce the loading conditions may require the exercise of considerable ingenuity. The simple form of linkage shown on Fig. 27(*a*) would give the kind of jack load/travel curve shown on Fig. 27(*b*). This linkage produces a load assisting jack extension and opposing closure, reversal of the bell-crank would reverse these conditions. The linkage may be designed so as to produce conditions in which the jack is opposed during the first part of extension and assisted during the remainder of the stroke, or vice versa.

Reaction Jack and Accumulator System.—This system is probably the best. There are no undesirable inertia effects to be considered, and very high loads can be applied within a



(a) Test rig



(b) Loading curve

Fig. 27—Deadweight System

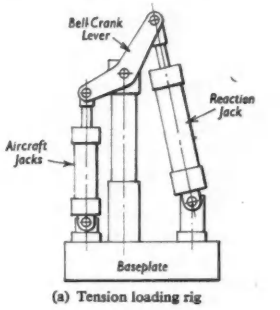
small space. By suitable linkage geometry between the aircraft and reaction jacks, and by carefully chosen accumulator volumes and compression ratios, almost any jack load/travel curve can be simulated within fairly close limits.

Examples of two kinds of rigs are shown on Figs. 28(*a*) and 28(*b*) and the load/travel curves on Fig. 22. These two rigs were, in fact, used to give the required loading conditions for two pairs of jacks operating bomb doors. The loading cases to be covered were operation under normal and excessive yawed flight conditions. It will be seen that the required loads were simulated with considerable accuracy.

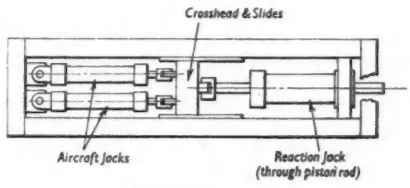
On the port door rig, the reaction jack is directly linked to the aircraft jacks. The reaction jack has a through piston-rod, giving equal areas, and on each side are accumulators of equal volumes, but differing inflation pressures and compression ratios. At the beginning of the jack travel, pressure in the accumulator nearest the aircraft jacks is higher, giving a tension load, and as the jacks continue to extend, this condition is reversed, giving a compression load.

On the starboard door rig, linkage is through a bell-crank lever, and only one accumulator is used on the annular area side of the reaction jack. The applied load is always tension.

Initial inflation pressures and compression ratios for the reaction accumulators are calculated to give the required loads (this is largely a matter of trial and error, with the benefits of past experience). Isothermal compression and expansion of the air volumes is assumed, but under operating conditions, compression and expansion is polytropic, and it is impossible to predict the value of the exponent, since this depends upon the air volume, compression ratio and operating speed. The calculated data can be used as a starting point, but final adjustment can only be done during preliminary tests. It has



(a) Tension loading rig



(b) Compression loading rig

Fig. 28—Reaction Jack Loading System

been found by experience that the effects of polytropic compression can be minimised by avoiding small air volumes and high compression ratios.

It is important that there should be a minimum amount of restriction to the flow of oil from the reaction jack to the oil side of the accumulators. The accumulators should be as close as possible to the reaction jack with maximum diameter straight-through connecting pipes wherever possible. If there should be undue restriction, then the pressures in the reaction jack will bear little relationship to the accumulator pressures, and it is the latter upon which the loads are calculated.

One source of error in this system is ring friction in the reaction jack and accumulators, which would result in the aircraft jack working against a greater load, or being assisted by a smaller load than is apparent from the observed pressures. Due to the widely varying pressures in the reaction system, it is not easy to calculate the ring friction throughout jack stroke, and in any case, the small amount of knowledge upon this subject does not lead to accurate estimates. However, the total ring friction is not likely to exceed 5 per cent of the total load and, where the maximum applied load is not critical,

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the effects of the increased load can be ignored.

Another source of error is friction in the lever bearings, and the same remarks apply as in the case of ring friction.

Where the maximum applied load on the aircraft jack is critical, either for strength considerations or if the operating pressure in the jack is close to the maximum system pressure, then the applied load must be accurately known. This is most easily achieved by strain-gauging the connecting links between the aircraft and reaction jacks, or by introducing a special strain-gauged strut. Recordings are taken with the aircraft jack operating, and the reaction circuit adjusted until the desired maximum load is attained.

Special Systems.—In some cases it may be necessary to reproduce the inertia effects due to the mass of a door or control surface, and the flexural stiffness of the surface. In addition, the complete aircraft operating linkages may be used in order to check correct functioning on the test rig.

A special rig incorporating the aircraft linkages and reproducing mass and stiffness effects was built to test the operation of a pair of large doors, and a full description is set out as this is probably one of the most interesting and complicated rigs built.

There are two operating jacks, one at each end of the doors. The jack piston-rods are fixed, and the cylinders move downwards to open the doors. The complete aircraft operating linkages were used. Movement of the doors was synchronised during opening and closing by synchroniser valves mounted on top of the rig, and the aircraft synchroniser operating mechanism was also reproduced. In addition, a method of varying the backlash in this mechanism was incorporated. Dummy doors were used, having the same weight as the aircraft doors, but being shorter in length to keep the rig as compact as possible. Torsional stiffness was represented by torsion bars connecting the front and rear ends of each door.

The loading cases were given as a moment about each door centre line and a side load component. Different loadings were applied at the front and rear ends.

The front end moment loading was obtained by fixing two separate cables to two arms on the port and starboard doors, the cables passing over pulleys on to a drum which was rotated as the doors opened and closed. Fitted to the main drum was a smaller drum on to which was fixed another cable passing directly to a reaction jack. The front end side loading was obtained by fixing two separate cables to points at the bottom ends of each door, these cables then passing over pulleys and being fixed to a drum as for the moment loading. Fitted to the main drum was a smaller drum on to which was fixed a cable passing to a quadrant pivoting about a fixed axis. Load was applied to the quadrant by a reaction jack fitted with a roller at the end of the piston-rod which moved along the face of the quadrant as it rotated, the movement being governed by a radius arm fixed to the roller. The loading diagram is shown on Fig. 23 and the door moment and side load curves plotted against jack travel on Fig. 24.

The rear end moment loading was obtained by fixing two continuous cables to two arms on the port and starboard doors. Each continuous cable passed around the circular track and a series of pulleys on to a drum which rotated as the doors opened and closed. Each drum was loaded by a common reaction jack through connecting-rods. The rear end side loading was obtained in an exactly similar manner, except that the continuous cables were fixed to points at the bottom ends of each door. The loading diagram is shown on Fig. 25 and the door moment and side load curves plotted against jack travel on Fig. 29.

Auxiliary Equipment.—The hydraulic power supply for a full-scale test rig must be the same as on the aircraft. For engine-driven pumps, the engine that is used to drive the pumps (either electric, petrol or diesel) must have a sufficiently wide speed range to cover all pump speeds likely to occur during take-off, flight and landing. Hunting and overspeeding when the pumps are off-loaded is a problem not easy to cure, even by using a governor. Most governors are not sufficiently responsive to deal with the very wide variation in power requirements (at least within the author's experience).

The power circuit should use the actual aircraft oil tank (or a tank of similar capacity) and a large volume tank. The former is used for acceptance tests for service functioning, and also in determining the maximum duty cycle for ground operation. Aircraft tanks are usually small, and prolonged running on the ground would make the oil too hot. The large tank is used for general purposes and endurance testing, the oil being passed through a cooler before going back to tank. Both tanks must be capable of being pressurised or evacuated to simulate high-altitude conditions with or without cabin blower boost.

Specialised Testing

It is difficult to place a limit on the kinds of tests to be included under this heading, as almost all basic research could be called "specialised testing." Examples of the most common test procedures will be given.

Climatic Testing.—Under normal conditions of service an aircraft operating from tropical airfields may stand for some hours in the sun and then take off and climb to an altitude of 40,000ft or more. This means that all hydraulic services must function correctly at temperature extremes of +70 deg. Cent. to −65 deg. Cent.

Purely hydraulic components are not likely to give much trouble at high temperatures, but with electro-hydraulic components, such as selectors and solenoid valves, there is a marked loss in available power at high temperatures due to increased electrical resistance. The high-temperature case then becomes the critical operating case, and thorough tests must be carried out to check functioning.

The equipment required is very simple, consisting only of an electrically-heated oven with thermostatic control, with the necessary instruments. The oven should be large enough to admit a small complete system—for example, a motor pump unit, accumulator, selector and jack. Electrical supply to the components should be controllable so that progressive reduction in voltage may be made to determine the minimum operating voltage under the most adverse conditions.

The behaviour of components at low temperatures is much more uncertain. Generally speaking, at low temperatures the mechanical properties of non-ferrous metals show a slight improvement, but there are certain steels which exhibit an increased notch sensitivity.

From the functioning angle, sealing rings tend to shrink and harden, resulting in failure to seal. Viscosity of the standard aircraft hydraulic fluid is approximately 100 times greater at −60 deg. Cent. than at normal temperatures, meaning that operation will be sluggish and, in some cases, not even possible.

It is therefore essential that all components should be tested for functioning and general behaviour at extremely low temperatures. A great deal of useful work can be carried out in the laboratory with a small refrigerator of about 5 cubic feet capacity, capable of going down to −70 deg. Cent. Unfortunately, the heat extraction rate of such a refrigerator is usually low and endurance tests exceeding 100 operations are generally out of the question owing to the time which must elapse between operations to ensure that the fluid is uniformly cooled. Certain critical services may have to be tested in their entirety in large low-temperature rooms. Such large-scale testing is generally beyond the scope of the average hydraulics firm, and recourse may be made to equipment maintained in Government research establishments.

The problems of operation at high altitudes at reduced atmospheric pressure are usually confined to hydraulic pumps, and then only when a non-pressurised supply tank is in use. These conditions are easily simulated in the laboratory and, having established the pump delivery curves at various equivalent altitudes, service operating times can then be predicted.

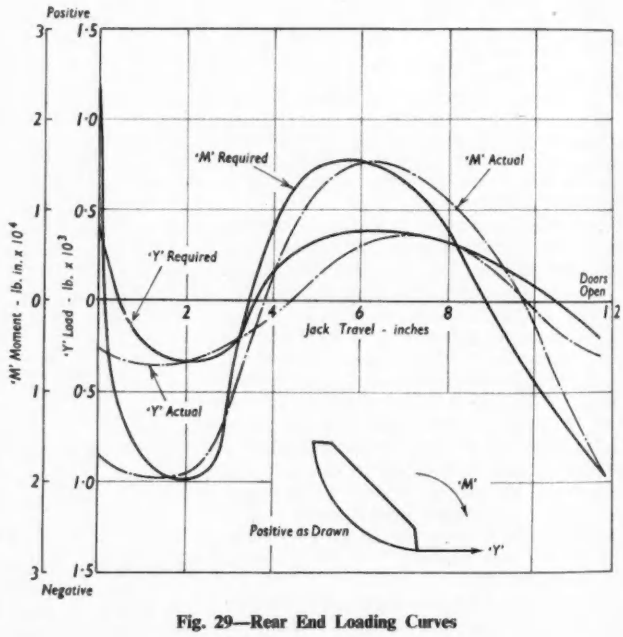


Fig. 29—Rear End Loading Curves

Oscillograph Testing.—Oscillograph equipment is essential for the investigation of pressure surges, valve operating times, loads, and many other factors affecting the performance of individual hydraulic components and complete systems.

Apart from the recording and photographic equipment, the apparatus used consists of pressure pick-ups to record pressures, potentiometers to record linear and radial movements, strain gauges to record loads,

and accelerometers. The instruments and apparatus and the techniques used are widely known, and it is not considered necessary to make any further reference.

In almost all cases of recording of transient phenomena, more than one trace must be recorded simultaneously. For example, when investigating the performance of a jack, it is necessary to record pressure on both sides of the jack and travel, all simultaneously against a time base. One method of doing this is to record each trace on individual cathode-ray tubes, and then bring all traces together for photography by a system of lenses and mirrors. As in some special tests, it may be necessary to do up to six traces simultaneously ; this method is liable to be complicated and expensive. Another method, perhaps more simple, is to use a multi-beam electronic switch, by means of which up to six traces are fed on to a common tube. Each trace then consists of a series of dots at 1 millisecond intervals.

Direct methods of recording on waxed paper using a stylus which is moved according to electrical signals received, are not generally recommended, as the system has a comparatively low limit of frequency response.

Conclusions

Any branch of modern engineering depends in its success on the co-operation of a number of specialists. In the field of hydraulic machinery it has been found that the test engineer is not the least important of these specialists.

Rig testing is an important phase in the development of the equipment, and as equipment becomes more extensive and complicated so the rigs used become more extensive and complicated.

The purpose of this article has been to outline some of the activities of one particular development shop in this field, in the hope that the methods used may be of interest to others, and that discussion of technique will lead to improved methods and new ideas.

Acknowledgments

Acknowledgment is made to the author's own firm for permission to publish this article and to many of his colleagues who have co-operated in the work carried out, in particular, Mr. R. Fairclough.

Appendix.—Development Test Schedule for Relief Valve

Static Tests.—Remove the spring to prevent the valve blowing off. Blank off the outlet and apply a pressure of 6000 lb per square inch at the inlet. Check diameter and length of body for distortion under pressure. There should be no permanent set after reduction of pressure to zero. Replace the spring.

Apply an increasing pressure at the inlet. The valve should blow off at 4800 lb$\pm$100 lb per square inch (adjust by shims if necessary). Relief pressure to be within the limits in twenty-five consecutive tests.

Apply an increasing pressure at the inlet until the valve blows off and make a careful record of the pressure at which the valve re-seals. This is to be done operating the hand pump handle, (*a*) slowly, (*b*) normally, and (*c*) in a series of rapid jerks.

These tests are to be carried out (*a*) with no capacity in the line, (*b*) with an accumulator in the line hydraulically full at initially zero pressure, and (*c*) with the accumulator inflated with air to 3000 lb per square inch.

In all tests the volume of oil in the circuit is to be ascertained.

In no case should the valve re-seal pressure be less than 4000 lb per square inch.

Vibration Tests.—The valve is mounted on a static bench with a small accumulator in the line. The pressure is increased from zero to maximum, striking the pipe near the valve during this process. Record the point of sensitivity to impact and the re-seal pressure.

The valve is to be vibrated at a frequency of 50 c.p.s. with an amplitude of 0·05in and with a pressure of from 1000 lb per square inch to maximum applied at the inlet. Record the minimum stable value.

Surge Tests.—The valve is connected to an engine-driven pump circuit with an automatic cut-out and small accumulator. Note whether there is any momentary spilling when the cut-out operates.

The valve is connected to the jack side of a three-way selector by a pipe ranging in length from 6in to approximately 120ft. The input side of the selector is connected to a small accumulator charged with fluid at 2500 lb, 3000 lb, 3500 lb, 4000 lb, and 4500 lb per square inch. The pipe from selector to valve is hydraulically full at the beginning of each test. Operate the selector rapidly, thus connecting the valve to the charged accumulator. Observe under what conditions spilling takes place.

Discharge Tests.—Connect the valve in an engine-driven pump circuit and record the discharge rates of flow and indicated back pressure up to a maximum of 5300 lb per square inch.

Endurance Tests. — Operate the valve 10,000 times under maximum conditions of indicated back pressure and discharge rates of flow.

Table I—*Comparison of Hydraulically Operated Services*

War-time fighter		Modern fighter	
The following services are operated hydraulically :—		The following services are operated hydraulically :—	
Main undercarriages		Main undercarriages	
Tail undercarriage		Nose undercarriage	
Landing flaps		Nosewheel centring	
Radiator flaps		Leading edge flaps	
		Trailing edge flaps	
		Air brakes	
		Tail parachute	
		Wheel brakes	
		Powered flying controls	
	No.		No.
Hydraulic pumps ...	1	Hydraulic pumps ...	2
Hydraulic jacks ...	11	Hydraulic jacks ...	26
Selector valves	3	Selector valves	7
Total of hydraulic components	25	Total of hydraulic components	98

These totals exclude components in wheel brakes and flying controls circuits.

Flood Control Works on the River Welland

No. I

The River Welland major improvement scheme envisages a number of civil engineering works to increase the run-off capacity of the river, so that floods in the Welland and River Glen can be safely handled. One of the major works of the scheme, the Spalding by-pass channel, was inaugurated last September ; other elements, principally flood relief channels in the upper Welland and from the Glen to the Welland will not be completed for two or three years.

THE fen lands of Lincolnshire are of particular interest to the civil engineer ; they present him with a challenge, for adequately drained or reclaimed they are, agriculturally, amongst the richest in the country, yet, by their nature, they are particularly vulnerable to floods. A great deal of attention has been given, since the formation of the river boards after the war, to various proposals for flood control works in these areas, and particularly since the very bad floods of the winter of 1947. The largest of the schemes proposed up to now concerns the River Great Ouse, where flood alleviation works have been designed, at an estimated cost of the order of £5,000,000, although constructional work on the scheme has not yet been started. But on another of the fen rivers, a scheme smaller than the Great Ouse scheme, but still the largest scheme so far to have been commenced in this country, has reached an advanced stage of construction. The Welland major improvement scheme has been in progress under the direction of the Welland River Board (formerly the Welland Catchment Board) since 1947, and when completed works to the value of some £1,500,000 will have been built to ensure the safety of the valuable fen lands flanking the Welland and the Glen rivers.

The accompanying map (Fig. 1) shows part of the Welland and the Glen catchments and the various channels and improvements of the new scheme. The Welland rises near Market Harborough in uplands about 700ft above sea level, and its total length from the source to the mouth of the river in the Wash is about 80 miles, and its catchment area about 390,000 acres. For the upper 50 miles or so of its course, it traverses, with fairly steep slopes, the upland hills, until it reaches the upper skirtland of the fens near Deeping St. James. From here onwards, the fens are generally at a level of several feet below the high water of spring tides, and the river flows through an embanked channel. In times of flood, therefore, the river acts as a high-level upland water carrier, throughout this part of its course, but it is also subject, at present, to tidal influence over most of this distance.

Much of the neighbouring fenland is drained by pumping stations ; for instance, Pode Hole pumping station drains the Deeping Fen into Vernatt's drain. However, to the south of the Welland a large area is drained by gravity into the River Nene through the South Holland main drain, a channel which was widened and deepened a few years ago. Although this area is not a part of the Welland catchment, it is directly influenced by the Welland and, in fact, during the 1947 flood, one of the breaches of the Welland's banks flooded part of it. Similarly, the contiguous area to the north of the Glen, the Black Sluice Fen, is influenced by the Glen, although it is in a different catchment area. The fen area draining into the Welland and Glen is about 80,000 acres in extent.

The River Glen rises near Grantham, and comprises two streams, which join at Wilsthorpe at the edge of the fen. For some 15 miles below Wilsthorpe the river is embanked and flows through the fen ; it discharges through tidal sluices into the Welland at Surfleet.

The Problem of Flood Protection

Before describing the various works of the improvement scheme, it is perhaps advisable to mention the condition of the river before the scheme was undertaken, and the various alternative proposals which were investigated. The average rainfall in the catchment is about

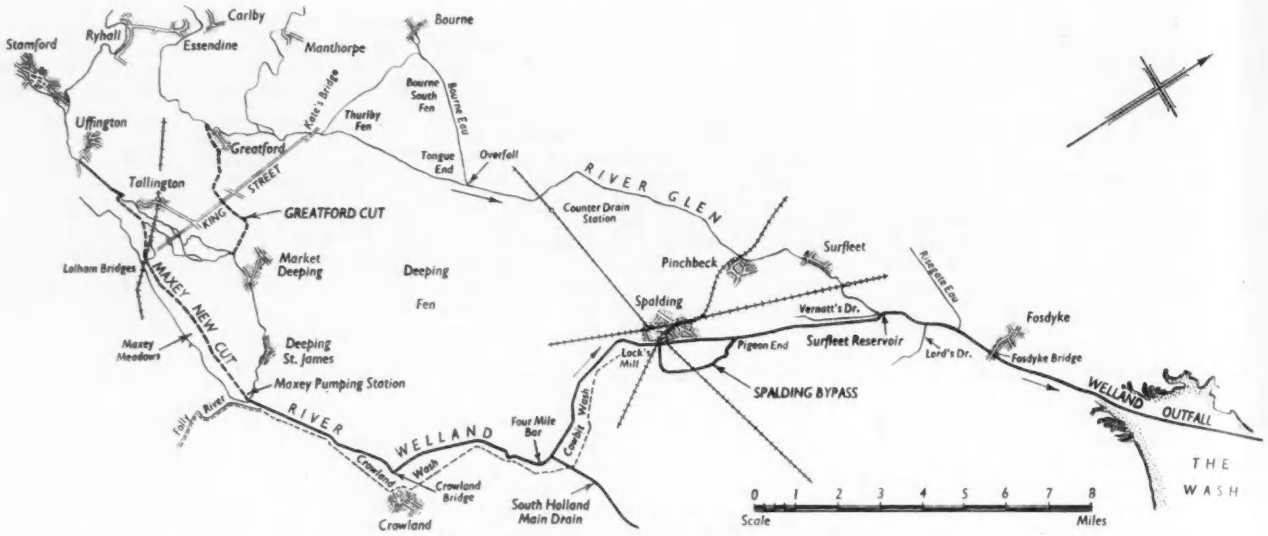


Fig. 1—Lower Part of the Welland and Glen Catchments

26in in the upland areas and about 23in in the fen. The upland streams have a fall of the order of 5ft to a mile, with a short "time of concentration," a high proportion of the rainfall being immediately apparent as run-off. Where the two chief rivers flow between embankments, the water level may rise to some 12ft above the general land level, so the "slope" of the channel is of necessity, small. Before the start of the scheme, the behaviour of the river in flood was largely governed by the Crowland and Cowbit Washes. These two large areas formed in effect flood reservoirs into which the river could spill. The capacity of the river channel from the washes downstream was rather limited, however, particularly through the town of Spalding, and so in most winters, flood waters would accumulate in the washes, and be drained away after the flood had passed its peak, the two washes being drained by a pumping station. The flood bank on the south side of these washes —the Crowland and Cowbit bank—commands the North Level and South Holland areas, and the flood bank on the north side of the river, the Deeping High Bank, commands the Deeping Fen area. These flood banks are therefore of major importance. The Deeping Fen is commanded on its north side by the southern flood bank of the River Glen ; the northern bank commands the Black Sluice area, and these two banks are also of major importance.

When comprehensive flood improvements of the catchment were first considered towards the end of the war, it was known that much concern had been felt for the various major banks mentioned above, on occasions when the Welland and Glen were in spate, and the banks of the Glen had been overtopped. Four alternative flood alleviation schemes were therefore considered, namely, (*a*) to improve the Welland and Glen independently, so that each river would be able to cope with its own flood discharges, leaving the catchment in its existing form. (*b*) To divert flood water in excess of that taken by the existing channel, from the Glen to the Welland through a diversion to Tallington ; to improve the Welland with new cuts from Tallington to Four Mile Bar, so as to take the augmented flow, and then to divert the major part of the flow southwards, through the South Holland main drain to the River Nene at Sutton Bridge. (*c*) To divert at Tallington, into the Glen, all the waters which the existing channel of the Welland could not take and then to improve the Glen below Kate's Bridge to take the augmented flow. (*d*) To carry out works practically the converse of the last proposal, viz. divert from the Glen at Greatford, all waters with which the existing channels of that river would be unable to deal, taking them in a new cut to the Welland at Market Deeping, then to confine works of improvement to the Welland, downstream of this new channel. In the event, the last alternative proved to have substantial advantages over the other proposals, and it is that scheme which is now in progress.

As a general basis for the design of the scheme (in 1944) a maximum run-off amounting to 11 cusecs per 1000 acres was assumed for the upland areas and a corresponding figure of 9·27 for the fen. The sizes required for the various river channels were deduced on this basis. Below Crowland and Cowbit washes, the main problem was to increase the capacity of the river channel through the built-up area of Spalding. After investigation of several possible alternatives it was decided that the most economical solution would be to widen the river, by constructing steel sheet piled retaining walls along each bank, for its passage through a small part of the town, and then to build a flood relief channel to skirt the remainder of the town, thus avoiding interference with existing amenities. Below the confluence of the flood relief channel and the river, widening could again be carried out. There was no problem with the estuary of the river, for, just before the war, works had been in progress to carry the main stream of the Welland out into the deep water of the Wash, thus improving the hydraulic gradient of the lower part of the river and obviating, to some extent, silting caused by tidal action. A channel had been excavated, to a depth of about −15ft O.D. (Liv.) and with a bottom width of 225ft, to join below Boston Cut End Lighthouse, with the deep channel of the Witham, from the port of Boston. Fig. 1 shows the position

Fig. 2—River Widening in Progress at Crowland Bridge. The Old River Channel is in the Foreground with the New Cut Behind

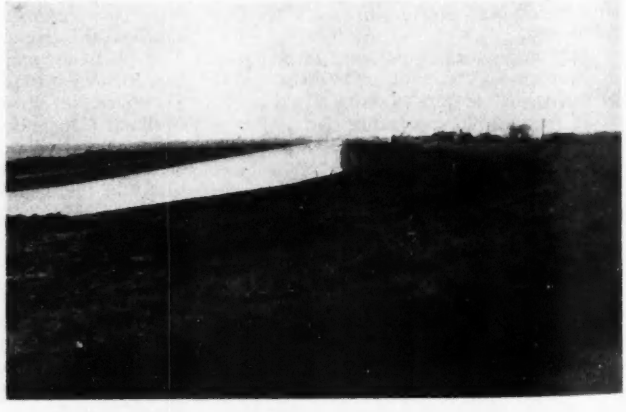


Fig. 3—Completion of River Widening at Crowland Bridge. The Old River Channel has been Filled, thus Forming a Berm to Protect the Flood Bank, as at Cross Section E, Fig. 4

of the channel. It is flanked by half-tide banks built to a level of +1 O.D. (Liv.), and protected from wave action with fascines and stone pitching.

The 1947 Floods

There remains one other factor, which has exercised a significant influence on the scheme. Just before work was started the fen rivers experienced, in the winter of 1947, the worst flooding for very many years. Towards the end of the very bad winter of that year, heavy rainfall occurred at about the same time as a general thaw, and the fen rivers burst their banks in many places, causing much damage. As far as the Welland and the Glen were concerned, breaches occurred in all four of the major flood banks mentioned earlier, in spite of the great effort which was made with emergency works and maintenance during the whole period, although these works undoubtedly prevented much heavier damage.

From various gauging readings taken during the flooding, flow figures were deduced which were then used as a basis for the flood alleviation works. These figures were checked against estimated flood discharges from the similar catchment areas of neighbouring rivers, and good agreement was obtained. The revised figures corresponded to a run-off of about 25 cusecs per 1000 acres in the uplands, 20 cusecs per 1000 acres for the marginal land, and 15 cusecs per 1000 acres in the fens. It is thought that the scheme as originally designed would have been able to cope with the 1947 flood, but not with any substantial margin of safety. During the flood period, it was estimated that the river at Spalding was passing, at its absolute maximum capacity, about 2000 cusecs. The level was then above the soffit of Spalding bridge, which thus acted as a check on the flow. It was also estimated that the flow into the Crowland and Cowbit washes was, at the peak, about 6000 cusecs. These 1947 flood flows exceeded all estimated or anticipated discharge figures. Such concrete confirmation of the potential magnitude of a flood in the Welland catchment meant, of course, a revision as far as the design of the new works was concerned, which were subsequently proportioned to take the worst, or, in some cases, worse conditions than were then encountered.

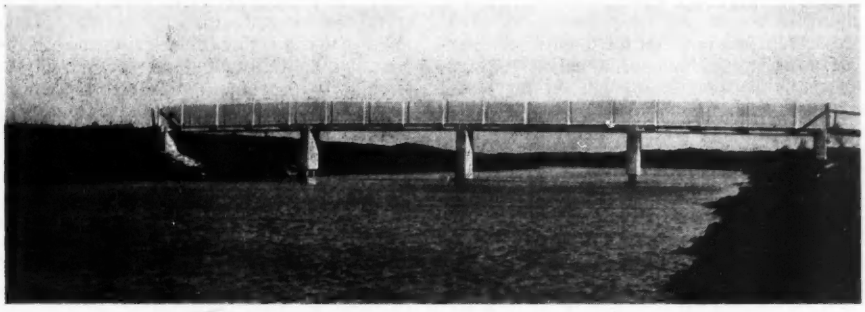
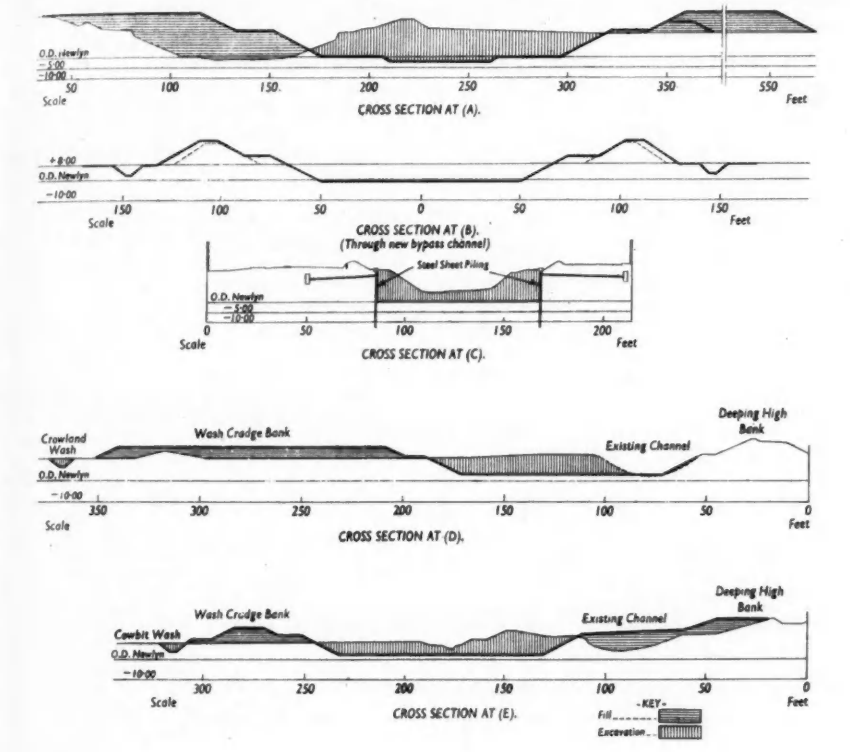


Fig. 5—Improved River Channel and New Footbridge at Four Mile Bar



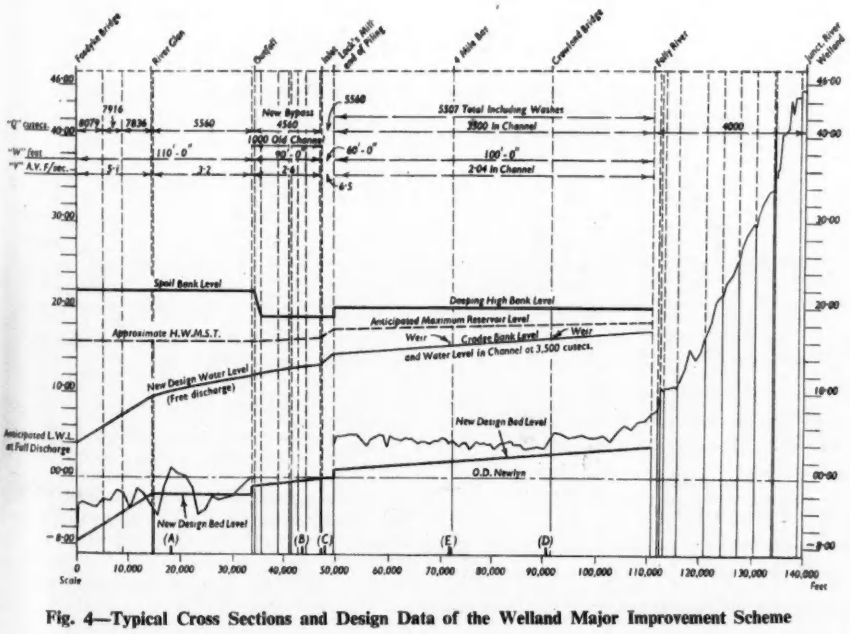


Fig. 4—Typical Cross Sections and Design Data of the Welland Major Improvement Scheme

The River Welland Major Improvement Scheme

Having now described the characteristics of the Welland catchment and the various factors which influenced the design of the new works, it remains to give some details of the works themselves. It will be recalled that, once the advantages of the present scheme over the alternative proposals had been demonstrated, the principal problem was to provide for flood discharges past Spalding. The basic element in the design of the scheme is therefore the flood alleviation channel which by-passes Spalding. This channel by-passes a length of about 1 mile of the Welland ; it is 2 miles long and has a discharge capacity of 4560 cusecs. It is closed at each end by sluice gates and it was necessary to build seven bridges across it to restore existing communications. The flood channel was officially opened on September 24th last by Sir Thomas Dugdale, the Minister of Agriculture. Below the confluence of the river and the by-pass channel, widening works have been completed right down to the Welland outfall. Above the channel a short length of the river has been widened between steel sheet piled retaining walls, and above this length widening has been carried out, and nearly completed as far as Folly River (Figs. 2, 3 and 5). Above this point a new channel is to be cut along the line of the Maxey drain (Maxey new cut) and on to Tallington, and a flood relief channel is to be excavated from the Glen (Greatford cut). The position of these works may be observed from Fig. 1. It will be noted that the Glen has so far had no relief,

and in the event of a major flood the situation along its length will again be critical. It is expected, however, that the Glen flood channel, as well as the Maxey channel, will be completed by the summer of 1955. At the present time some preliminary work is in progress on the various bridges which will be built across the Maxey Cut and Glen flood channel. One other important element will be built in the spring, namely, a navigation lock on the Welland about 100ft in length and 30ft in width, just upstream of the confluence of the Welland and the Spalding by-pass channel. This lock will prevent any tidal influence being felt upstream of it, and will allow the passage of boats, barges and small craft up to and about Spalding. Data relating to the various elements of the scheme are shown in the longitudinal section in Fig. 4, together with some typical cross sections before and after improvement at various places. The designed flood flows Q, channel width W, and the corresponding velocities V and water levels may be noted. For comparison the average flow of the Welland is 300 cusecs (approximately). The tidal effect on the lower part of the river is clearly shown; when the lock is built, tidal influence will, however, be limited to the river below the lock and by-pass channel.

(To be continued)

Improving Modern Locomotive Performance

By O. S. NOCK, B.Sc., M.I.C.E., M.I.Mech.E.

No. II—(*Concluded from page 205, February 5th*)

The long life of British locomotives, and the high capital value represented by many hundreds of existing engines of relatively recent design, makes it necessary to do all that is possible to improve performance and to render engines less susceptible to inferior fuel. In a notable paper before the Institution of Locomotive Engineers Mr. S. O. Ell revealed some recent test results obtained with the former G.W.R. "King" class. In this second article the author refers to some fine individual runs made with the dynamometer car, and then adds details of some footplate experiences of his own on the modernised engines.

IN his paper on locomotive testing developments, to which special reference was made in the first article last week, Mr. Ell gives complete details of one eastbound run from Stoke Gifford to Reading, on which the steaming rate—steam to cylinders—was 28,700 lb per hour. The load was made up to twenty-three coaches, 781 tons behind the tender, and details are shown graphically in the accompanying Fig. 8. The results shown in Table I were obtained from this one run. The speeds relate to the period of the test at constant evaporation, during which there was a check to 15 m.p.h. approaching Didcot. The engine was worked with the live steam injector only, and to obtain comparative results with the exhaust steam injector the coal consumption should be reduced by 9·5 per cent, thus showing an overall figure of 3·02 lb per drawbar horsepower hour. It will thus be seen that a high standard of efficiency is maintained even though the steaming rates have been substantially increased.

TABLE I

Average speed (excluding braking section)	61·7 m.p.h.
Average speed, Badminton to Steventon	68·5 m.p.h.
Coal consumption :	
Per available d.h.p. hour	3·33 lb
Per i.h.p. hour	2·108 lb
Per square foot of grate area per hour	121 lb
Boiler efficiency	63 per cent
Temperature of admission steam	684 deg. Fah.
Maximum speed	81 m.p.h.

On one occasion the author of these articles was privileged to travel in the dynamometer car on a test when a still higher rate of steaming was successfully maintained—30,000 lb per hour. The load was then twenty-five coaches, 796 tons behind the tender; the running was not quite so fast as on the journey shown graphically in Fig. 8, but the performance of the engine in both directions was none the less remarkable for that. On the eastbound journey, on which a start-to-stop average speed of 57·3 m.p.h. was achieved, the pass-to-pass average from Badminton to Steventon was 65·7 m.p.h., with a maximum of 78 m.p.h. at Little Somerford. On the graph shown in Fig. 8 the running may have been slightly assisted by a favourable wind, having an average natural velocity of 7 m.p.h. at an average direction of 27 deg. to the tail of the train. On the westbound run on the day I travelled the test was concluded on passing Badminton,

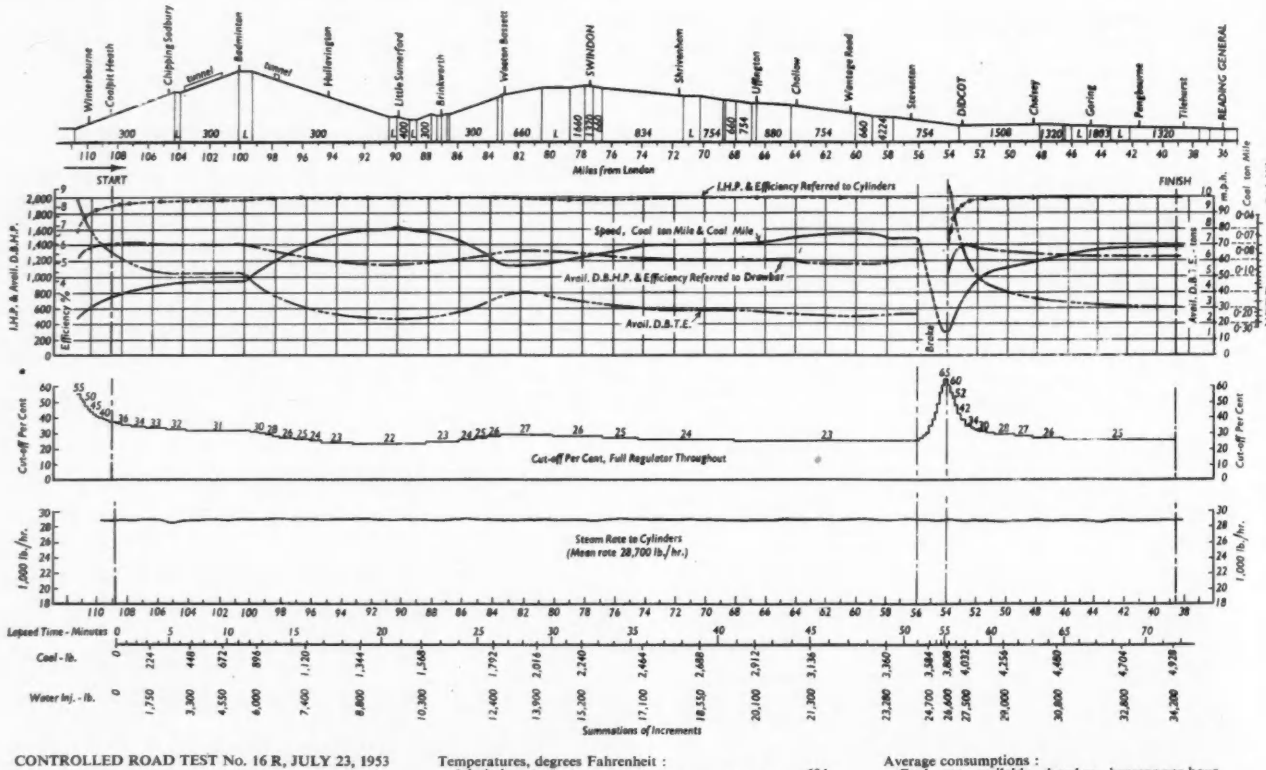


Fig. 8—Details of Test Run from Stoke Gifford to Reading

CONTROLLED ROAD TEST No. 16 R, JULY 23, 1953

Testing unit, W.R. dynamometer car; Markham coal of 14,510 B.Th.U. per pound as fired; live steam to injectors only; load, 781 tons (twenty-three coaches); wind, average natural velocity, 7·07 m.p.h.; average direction, 27 deg. to tail.

Mean steam and water rates, pounds per hour :

Actual feed water and cylinder steam	28,700
Equivalent f. and a, 212 deg. Fah.	39,160

Temperatures, degrees Fahrenheit :

Admission steam	684
Feed water	62

Mean coal rates :

Total rate, pounds per hour	415·0
Pounds per square foot grate per hour	121
Boiler efficiency, per cent	63

Average speed, miles per hour :

Excluding braking section	61·7
Badminton–Steventon	68·5

Average consumptions :

Coal per available drawbar horsepower hour, pounds	3·33
Coal per indicated horsepower hour, pounds	2·108
Water per available drawbar horsepower hour, pounds	23·0
Water per indicated horsepower hour, pounds	14·58

Adjustment for exhaust steam injector :
Reduce feed water consumption by 5·4 per cent.
Reduce coal consumption by 9·5 per cent.
Multiply efficiency and divide coal per ton-mile and coal per mile by 1·095.

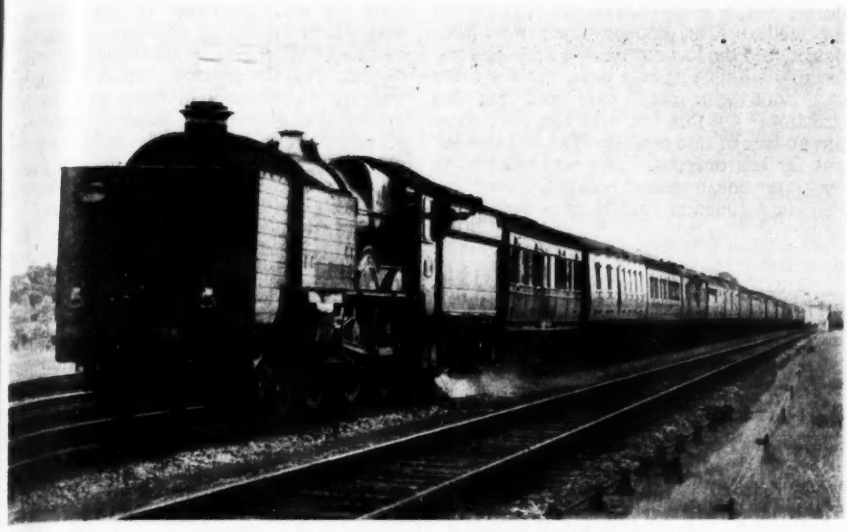


Fig. 9—" King " Class Engine, with 781-Ton Load

so that opportunity would be available to let down the fire before the long period of waiting prior to the return run. The test extended over a distance of 61 miles, from the 39½ milepost to a point just to the west of Badminton station ; over the 58·4 miles from Pangbourne station to Badminton, against the gradient, speed averaged 58·2 m.p.h. The merit of this average is enhanced by the fact that speed had to be reduced to 50 m.p.h. for the facing junction at Wootton Bassett in the middle of a stretch that could otherwise be covered at high speed. As observed from the gauges in the dynamometer car, the engine steamed with constant freedom, and the general opinion of those who travelled on the footplate was that 30,000 lb per hour did not represent the limit of her capacity. The lengthy wait at Stoke

TABLE II.—*W.R. Dynamometer Car Controlled Road Test. Load : Twenty-five Bogie Coaches* 796 *Tons Tare. Engine : Four-Cylinder* 4–6–0, *No.* 6001, "*King Edward VII.*"

Distance, miles		Time, min. sec.	Speeds, m.p.h.
0·0	Scours Lane Junction	0 00	Pass slowly, 10 m.p.h.
0·9	Tilehurst	2 25	—
2·7	Milepost 39½	Start of test	
3·8	Pangbourne	6 48	47
7·0	Goring	10 40	53½
8·7	South Stoke Box	12 35	56½
10·7	Cholsey	14 44	56
15·3	Didcot	19 32	58
18·7	Steventon	23 03	58
22·6	Wantage Road	27 02	60
26·1	Challow	30 36	59
28·7	Uffington	33 16	59
31·2	Knighton Crossing	35 51	58½
33·8	Shrivenham	38 26	61½
36·0	Marston East...	40 37	60
39·5	Swindon	44 09	60
42·2	Hay Lane Box	46 45	64½
—	Studley Box	48 10	66
45·1	Wootton Bassett	49 43	50*
49·2	Brinkworth	53 51	67½
51·9	Little Somerford	56 14	72
54·2	Post 92	58 18	62½
56·4	Hullavington	60 36	—
57·2	Post 95	61 24	56
58·2	Post 96	62 30	54
59·2	Post 97	63 36	53
60·2	Post 98	64 44	53
61·2	Post 99	65 53	52
62·2	Badminton	67 02	End of test
66·8	Chipping Sodbury...	71 40	60
70·7	Coalpit Heath	75 22	65½
73·7	Stoke Gifford East	78 36	—
74·2	Stoke Gifford West ... arr.	80 02	

* Speed reduced by brakes for junction.

Gifford before the return run was necessary to secure a clear path. The tests were made on week ends amid the ordinary traffic.

To indicate what a steaming rate of 30,000 lb means in running times and speeds the accompanying logs are given in Tables II and III. On the outward journey the speed sustained up the 10 continuous miles at 1 in 300 from Little Somerford to Badminton will be noted. Over the last 5 miles the drawbar pull was approximately 4½ tons and the drawbar horsepower related to level track approximately 1600. On both these runs one could not fail to be impressed by the keenness of the driver and the two firemen. Very great care was taken by the driver to maintain the required steaming rate at all speeds, by adjustment of the cut-off ; for most of the distance, so I was told, the reverser was not " set " at all, and was often held midway between adjacent notches so as to keep the manometer reading exact. It is a pleasure to put on record the names of the enginemen concerned, all from Swindon shed: Driver Hinder, and Firemen Shurmer and Green. Though both firemen travelled on the footplate in both directions, Shurmer did the actual firing on the outward journey and Green on the return. The coal rate was approximately 4000 lb per hour, which is, of course, well above the limit of 3000 lb now generally considered the maximum for one fireman.

Steam and coal rates such as those maintained on the test runs with twenty-three and twenty-five bogie vehicles are comparable with the very high rates that were habitually sustained on some runs in America prior to the general changeover to diesel-electric traction. Indeed, in his presidential address to the Institution of Locomotive Engineers in September last, Mr. R. C. Bond expressed his view that such habitually high steam rates, and the heavy boiler maintenance resulting from them, might well have been an important contributory factor towards the superseding of the steam locomotive in America. In any event one may be very sure that no train schedules involving continuous outputs of such order are likely to be contemplated in Great Britain, and that the enhanced steaming capacity of the " Kings " (Fig. 9) and other engines treated, such as the E. and N.E. Region " V2 " class 2–6–2, will be kept as a margin of power for use in exceptional circumstances, but more importantly perhaps as a margin to set against indifferent steaming, when inferior coal has been loaded on to the tenders. By courtesy of the Western Region authorities I

TABLE III.—*W.R. Dynamometer Car Controlled Road Test. Load : Twenty-five Bogie Coaches,* 796 *Tons Tare. Engine : Four-Cylinder,* 4–6–0, *No.* 6001, "*King Edward VII.*"

Distance, miles		Time, min. sec.	Speeds, m.p.h.
0·0	Stoke Gifford East Box, dep.	0 00	
0·75	Post 110¼	3 48	—
1·5	Post 110	5 25	—
1·6	Winterbourne...	5 45	Start of test
3·0	Coalpit Heath	8 09	—
4·3	Westerleigh Junction	10 18	40
6·9	Chipping Sodbury...	13 58	42½/45
11·5	Badminton	20 06	45½
17·3	Hullavington	25 58	72
21·8	Little Somerford	29 32	78
24·5	Brinkworth	31 47	71
28·6	Wootton Bassett	35 43	58
31·5	Hay Lane Box	38 48	56
34·2	Swindon	41 34	60
35·5	Post 76	42 52	62
37·8	Marston East...	45 00	64
40·0	Post 71½	47 00	68
42·5	Knighton Crossing	49 13	67
45·0	Uffington	51 24	69
47·6	Challow	53 40	69½
51·1	Wantage Road	56 38	70½
55·0	Steventon	59 57	71
58·4	Didcot	62 48	71
62·5	Post 49	66 20	End of test
65·0	South Stoke	68 30	68½
66·7	Goring	70 03	67
70·0	Pangbourne	72 57	67
71·5	Milepost 40	74 25	60
72·8	Tilehurst	75 50	—
73·5	Scours Lane Junction. arr. Up home signal	76 55	

have been privileged to observe from the footplate something of the working of the modernised engines in ordinary service conditions ; in each case, however, the fuel was good, and the interest of the journeys lay in the supreme ease with which fast and heavy trains were operated. Runs were made as follows :—

(*a*) Newton Abbot West signals to Paddington, non-stop : 194 miles in 200 min.; load 425 tons.

(*b*) Newton Abbot station to Paddington : 193·7 miles, with three booked stops ; total running time 215 min ; load 500 tons.

The first of these runs was made with the engine that provided the performance data quoted in Mr. Ell's paper, namely No. 6001, " King Edward VII." The train was the eastbound Cornish Riviera Express booked non-stop from Plymouth to Paddington. The maximum tare load allowed to unassisted engines of class " 8 " capacity is 360 tons over the exceptionally severe gradients of the South Devon line, and so far no special relaxation of this limit has been made for

AVERAGE SPEEDS:-
Stoke Canon to Whiteball.

Engine	Load (tons)	M.P.H.
6001	425	58·6
6023	500	53·0

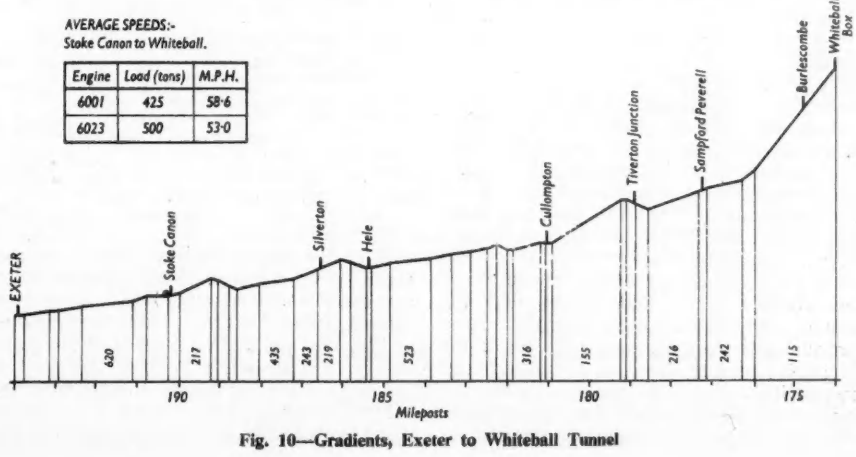


Fig. 10—Gradients, Exeter to Whiteball Tunnel

"King" class engines fitted with the new front end arrangements. With a twelve-coach train of 396 tons tare we were therefore provided with an assistant engine to Newton Abbot West, and the real interest of the journey began at this latter point. The driver and fireman, Messrs. Hammett and Henwood, of Laira shed, Plymouth, had not been on this particular engine since modification, and I fancy the freedom of the steaming took them a little by surprise. The safety valves were blowing off on several occasions, whereas the majority of Western Region men endeavour to keep the pressure just up to "sizzling" point, with the white feather showing, but without full blowing-off. With the direct loaded safety valves of Great Western design it is possible to maintain the "sizzling" pressure readily. On this run with the Cornish Riviera Express the departure from Newton Abbot West was a minute late, due to a slight delay in detaching the assistant engine; but the running was quite restrained at first, over the coastal stretch through Teignmouth, Dawlish and Starcross, with its many curves. The 20·5 miles from the restart to passing Exeter occupied 26¼ min and fast running began from this point.

The booked allowance for the 173·5 miles from passing Exeter to the stop at Paddington is 178 min and our actual time turned out to be 174 min. Except for a momentary sight of an adverse distant signal at Norton Fitzwarren the road was clear throughout, and there were no temporary speed restrictions due to engineering works on the line. Between Exeter and Fairwood Junction (Westbury) the 76·5 miles were covered in 74¾ min; this was distinctly faster work than that required with the corresponding trains of pre-war days, though during that spell of running the cut-off was not advanced beyond 17 per cent except for two short spells of 5 min each. The gradients on the two lengthy adverse stretches from Exeter to Whiteball Tunnel, and from the Athelney marshes up to Brewham summit in the Mendip country are shown in Figs. 10 and 11 herewith. The average speeds from Cowley Bridge Junction to Whiteball, and from Curry Rivel Junction to Brewham were 57·7 and 60 m.p.h. respectively. The maximum cut-offs used were 20 per cent for the last 3 miles up to Whiteball (minimum speed 47½ m.p.h.) and 22 per cent from Bruton to Brewham (minimum speed 44 m.p.h.). But what impressed me more than any details of the running times and speeds was the extreme freedom of the steaming. On a previous run with this same train on engine No. 6022, not long after that engine had been fitted with a much enlarged superheater, we made average speeds of 53·5 and 52·9 m.p.h. over the two uphill stretches referred to above, with a gross load of 450 tons behind the tender. The booked times were then slower, and the locomotive was running comfortably within schedule time, but the firing was done with great care and constant attention. On this run with No. 6001 there was no lack of care and attention, but the task was far less onerous. This was reflected in the water consumption between Exeter and Fairwood Junction, which amounted to no more than 2200 gallons, or 29 gallons per mile.

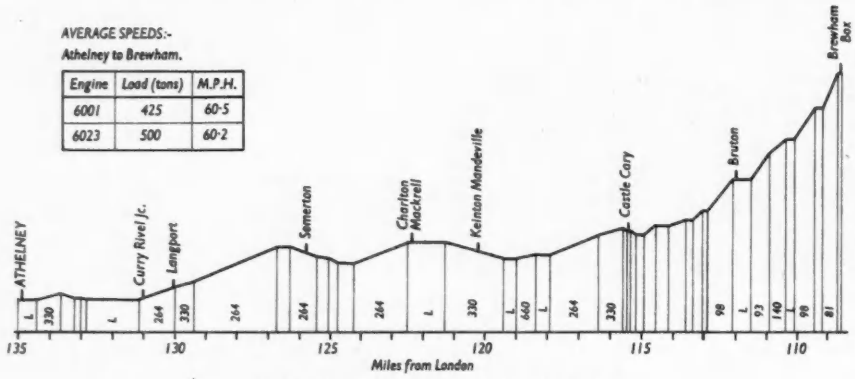


Fig. 11—Gradients, Athelney to Brewham Box

I have chosen Fairwood Junction as a division point in the journey, as the second stage consisted for the most part of much easier running. The gradients are more favourable, and although an average of almost 60 m.p.h. was sustained over the 97 miles to the stop in Paddington the water consumption was no more than 2250 gallons, or 23 gallons to the mile. We had about 10 min of reasonably hard going—that is with 15 to 17 per cent cut-off and the second regulator valve just cracked, but other than that the steaming was very easy. Savernake summit, 103·4 miles from Exeter, was passed in 101½ min and had we finished in the style, of a normal pre-war run—in 65 min for the concluding 70 miles—our overall time of 165½ min would have shown an average speed from Exeter of 63 m.p.h. As it was we took 72½ min. But the skill and economy with which the engine was worked was outstanding. As usual, we were running with a big fire, built up haycock fashion, and things were so comfortably in hand that the last appreciable firing took place at Newbury, 53 miles out of Paddington. After that the fire was gradually worked down; the long rake was used at intervals to spread the coal and keep the bars evenly covered, and on passing Iver, when 14 miles out, a few shovelfuls of slack were spread thinly over the grate. Thus in working a 425-ton train from Exeter to Paddington at an average speed of 60 m.p.h. the total water consumption did not exceed an average of 26 gallons per mile, and the coal consumption was approximately 30 lb per mile. The maximum indicated horsepower, judging from the Swindon test results on this engine, would appear to have been about 1600, reached between Tiverton Junction and Whiteball, and again near Bruton, where cut-off was increased to 22 per cent while travelling at 53 m.p.h.

Even more satisfactory, perhaps, was the run of engine No. 6023, "King Edward II," on the 9.28 a.m. express from Newton Abbot to Paddington, worked by Driver Solomon and Fireman Lewis, also of Laira shed. On the previous run with No. 6001 we had with us on the footplate Inspector C. J. Pullen, of Swindon, who had ridden on the engine during the controlled road tests with the dynamometer car. On engine No. 6023 we had with us Inspector Button, of Newton Abbot. Direct comparison with the run of No. 6001 on the Cornish Riveria Express is not possible, due to the station stops at Taunton and Westbury; but in Table IV a comparison of the passing times on the three successive stages is shown between stations and other timing points where practically full speed was being run on the second journey. For example, in accelerating from Exeter speed had reached 45 m.p.h. at Stoke Canon, while at Norton Fitzwarren it was still high, before the brakes were applied for the Taunton stop. In consideration of the heavier load the work of engine No. 6023 was really excellent. Although the speed on

TABLE IV.—*W.R. Runs Between Exeter and Reading.*

	Distance, miles	6001 Time, min. sec.	6023 Time, min. sec.
Engine ("King" Class), No.		6001	6023
Load: Coaches		12	14
Tons tare		396	465
Tons gross		425	500
Train		Cornish Riviera	8.30 a.m. from Plymouth
Exeter–Taunton Stage:			
Stoke Canon–Whiteball	16·5	16 53	18 40
Whiteball–Norton Fitzwarren	8·9	7 43	7 03
Total	25·4	24 36	25 43
Taunton–Westbury Stage:			
Cogload Box–Castle Cary	22·8	21 24	21 48
Castle Cary–Brewham Box	6·8	7 49	8 04
Brewham Box–Fairwood Junction	11·4	10 28	11 16
Total	41·0	39 41	41 08
Westbury–Reading Stage:			
Lavington–Savernake	16·8	17 19	17 15
Savernake–Southcote Junction	32·2	30 36	30 02
Total	49·0	47 55	47 17
Grand total	115·4	112 12	114 08
Average speed	115·4	61·7	60·8
Total time Exeter to Southcote Junction, including stops on run with engine 6023	135·6	min. sec. 132 06	min. sec. 157 00
Total water consumption, Exeter to Southcote Junction, including stops, braking and accelerating time on run with engine 6023	—	3950 gallons	4650 gallons
Total water consumption in gallons per train mile	—	29·1	34·4
Reading to Paddington			
Load: tons tare/gross		396/425	397/425
Time for 36 miles pass to arr. stop		Min. sec. 39 13	Min. sec. 39 58

the open stretches of the line was little, if anything, slower than No. 6001, the total time from Exeter to Southcote Junction (nearing Reading) was nearly 25 min longer due to the station stops and the periods of braking and accelerating. The train stood for 4¾ min at Taunton and for 8 min at Westbury. Yet despite this disadvantage the water consumption was no more than directly proportioned to the loads hauled. By comparison with the readings obtained on engine No. 6001 it seemed to me that the cut-off indicator on engine No. 6023 was reading 2 or 3 per cent low. For example, in making almost identical speed between Cogload and Castle Cary the driver of No. 6023 had the reverser showing 15 per cent cut-off all the time, whereas the adjustment on No. 6001 on this same stretch varied between 15 and 17 per cent. The latter engine had not long been returned to ordinary traffic after the series of stationary and controlled road tests, and the setting of her reverser would no doubt be quite accurate.

On the second journey we were stopped by adverse signals outside Reading, and held for 1¾ min. Fortunately, however, when the signal cleared we got the full "right-away" and were able to detach the slip coaches in Reading station while accelerating rapidly. But the delay cost 4½ min in running, despite which the final arrival in Paddington was a minute early. The actual overall time for the 95·6 miles from Westbury was 105 min and the net time 100½ min. Between Reading and Paddington the load of the 8.30 a.m. ex-Plymouth was exactly the same as that of the Cornish Riviera and both trains were run under very easy steam. It was not that the engines were incapable of more, with dirty fires or other disabilities; indeed, on passing Reading the driver of No. 6001 asked outright: "What do you want now, 60 m.p.h. or 80?" It was as easy as that! But we were well on time already, and spectacular though an 80 m.p.h. sprint would have been in winding up a fine trip, it would have taken us far ahead of schedule time. As to No. 6023, some of her finest work was done between Exeter and Taunton. On the last stage of the climb to Whiteball speed fell only from 58 to 46 m.p.h. in 2 miles of 1 in 115 gradient, and with the speed limit completely removed over this main line we had a very rapid acceleration down the Wellington bank. With no more than the first port of the regulator open speed rose to 58 m.p.h. in 1 mile from the summit and to 73 m.p.h. in another mile. Wellington station was passed at 84 m.p.h., and on the continuation of the descent on gradients averaging about 1 in 200 speed rose to a maximum of 92 m.p.h. At this speed, and throughout the descent from Whiteball, the engine rode very smoothly.

TABLE V.—*Runs with Modified Engine No. 5025, "Chirk Castle."*

Train from Paddington		1.15 p.m.	5.5 p.m.
Load, tons, tare		363	341
Load, tons, full		395	370
Distance, miles		Time, min. sec.	Time, min. sec.
0·0	Paddington	0 00	0 00
9·1	Southall	13 22*	12 36
18·5	Slough	22 45	20 57
36·0	Reading	39 08	35 45
—	—	—	Sig. check
53·1	Didcot	54 19	54 06
—	—	—	Sig. stop
66·5	Uffington	67 21	71 03
—	—	Sig. stop	—
77·3	Swindon	82 42	81 45
94·0	Chippenham	96 40	96 00
—	—	Sig. check	—
101·6	Box	104 44	103 10
106·9	Bath	110 00	108 12
Net running time, min		103	100
Net average speed, m.p.h.		62·3	64·2
Max. sustained speed on level track, m.p.h.		69	75
Max. speed on Dauntsey bank, m.p.h.		85	81

* Slight signal check near Southall.

The modified front-end arrangements have also been applied to certain engines of the "Castle" class. With the stationary testing plant very fully occupied it has not yet been possible to subject the new arrangements to full analytical tests, but to judge from the working of the modified engines in ordinary traffic it would seem that the design, straight from the drawing board and without further development, has provided almost ideal proportions. In travelling as a passenger I have several times lately encountered engine No. 5025, "Chirk Castle," and after one successful run had a short talk with her crew. The talk produced this candid comment: "She's always been a good engine, but now she's an absolute 'smasher.' She'll burn anything!" I have not yet had any footplate experience with modified engines of the "Castle" class, but these articles may be appropriately concluded by some brief details of recent running by the "Chirk Castle."

The accelerated Bristol expresses, booked to cover the 106·9 miles from Paddington to Bath in 106 min start to stop, are in many ways a more difficult proposition than the corresponding trains of pre-war days. Then the timing was 102 min, but on the heaviest service a slip portion was detached at Didcot. Thus although the load was around 400 tons when leaving Paddington, it was usually less than 300 for the second half of the journey. To-day the 1.15 p.m. down carries a tare load of 360 tons throughout. With this latter train, and engine "Chirk Castle," we steadily gained on booked time, passing Didcot (53·1 miles) in 54¼ min. Then a bad signal delay occurred at Knighton Crossing, 69 miles from Paddington, where the train was brought to a dead stand in 70 min from the start. The restart, with the driver no doubt anticipating further checks, was a little slow; but from Shrivenham, where the goods train that had caused the delay was passed, he pressed on with vigour, and some fast running was made west of Swindon. The short descent of 1½ miles at 1 in 100 into the valley of the Wiltshire Avon witnessed an acceleration from 71 to 85 m.p.h. and the train passed Chippenham (94 miles) in 96¾ min, despite the signal stop, which had cost fully 5 min in running. Summary details of this run, and of a more spectacular run with the same engine, but with a different driver and fireman, are given in Table V.

This second run was on the 5.5 p.m. train, which has not yet been accelerated. The timing to Bath is 114 min, showing a booked average speed of 56·2 m.p.h., against the 60·5 m.p.h. of the 11.15 and 1.15 trains. But the start was 2 min late. By vigorous running and a maximum speed of 75 m.p.h. on level road this lateness was quickly recovered. Further checks followed; but the response from engine and crew was as successful as it had been earlier in the run, and Chippenham was passed a minute ahead of time. The recovery minutes allowed between the latter station and Bath were not needed and the arrival was 4 min early. The net running times, over 106·9 miles, of 103 min with 395 tons and 100 min with 370 tons show very sound work, especially on the first run, on which no special effort other than that of service requirements was being made over the first 65 miles of the journey.

These articles describing testing work and developments at Swindon have naturally dealt with locomotives of Great Western design. But the finer points of front-end design and proportioning are applicable no less to many engines of pre-nationalisation design working on other Regions, and it seems probable that with the information made generally available through the work of the Locomotive Testing Committee of British Railways we may look forward to equally interesting developments elsewhere.

Trans-Mountain Oil Pipeline in Canada

The discovery of new oilfields in the Province of Alberta meant that there was a surplus of oil over local requirements and that new markets were essential to further development. A potential market existed in British Columbia and the Pacific Northwest, where consumption of petroleum was rising rapidly, and so a pipeline to link Alberta with the West Coast was designed and built. The line, which is 718 *miles in length, extends from Edmonton to Vancouver and has a daily capacity of* 200,000 *barrels.*

THE two principal factors which brought the trans-mountain oil pipeline into being were the continued expansion and development of Alberta crude oil reserves since the discovery of the Leduc oilfield in 1947, and the pyramiding increases in population together with higher per capita consumption of petroleum in British Columbia and the Pacific Northwest. Studies made during 1950 indicated the practicability of building an oil pipeline from Alberta to the West Coast and as a consequence the Trans Mountain Oil Pipe Line Company was formed. The only important earlier crude oil production in Canada during 1946, about 20,000 barrels daily, came from Turner Valley, near Calgary. The petroleum needs of the Prairie Provinces of Alberta, Manitoba and Saskatchewan were met only in part from oil refined locally, about half of this oil being imported by tank car from Montana and the mid-continent fields.

Following the discovery of the Leduc field in February, 1947, and of the Redwater field in 1948, enough oil was soon at hand in Alberta to serve all local requirements, and in fact additional outlets had to be found if this potentially great development was to proceed.

The first step was to move the oil eastward to supplant imports into not only Saskatchewan and Manitoba but also the Western Ontario refineries, and for this purpose, during 1950, the 1127-mile long Interprovincial pipeline was built from Redwater via Edmonton to Superior, Wisconsin, from whence it was shipped by lake tanker to Sarnia, Ontario.

In studying the trans-mountain project first consideration was given to the Alberta reserves, and the estimated recoverable oil at October 1, 1951, was 1330 million barrels, at January 1, 1953, was 1679 million barrels, and approximated 2000 million barrels at January 1, 1954. The market for Alberta oil in British Columbia was obvious, since the Vancouver area refineries imported their crude oil supplies almost entirely from California, and it was evident that a trans-mountain pipeline could serve them with Alberta oil at equal or less cost. By providing a marine terminal at Vancouver, Alberta oil could be conveniently loaded for export to other consuming areas, and in California, the increasing disparity between local production and demand indicated a possible market if the Canadian oil could be delivered at a cost ensuring better financial returns compared with those obtained from crude oil from more distant sources. With

imports of petroleum products into the Pacific Northwest States exceeding 250,000 barrels daily, it appeared obvious that refineries would be built in the Puget Sound area, which could be served by a spur line and further ensure the economic feasibility of a trans-mountain line.

Extensive surveys determined the best location for the oil pipeline, the probable capital requirements and operating costs, and confirmed the economic soundness of the project. An operating company was formed to design and build the pipeline, and the company received its Dominion Charter on March 21, 1951, by Special Act of the Parliament of Canada, and was also granted, on December 13th, a permit by the board of Transport Commissioners for Canada, to construct and operate an all-Canadian crude oil pipeline from the vicinity of Edmonton, Alberta, to the vicinity of Vancouver, British Columbia. A later permit was granted to extend a spur line from Sumas to the Canadian-U.S. boundary in anticipation of pipeline deliveries to Puget Sound refineries. Topographical maps of the Rocky Mountains disclosed only two practical routes between Edmonton and Vancouver, an international route from Edmonton through Crows Nest Pass, Spokane and Seattle, and an all-Canadian route from Edmonton over Yellowhead Pass and through British Columbia. Comparative estimates of construction and operating costs indicated that the all-Canadian route involved the lowest costs, and would require a smaller tonnage of steel, which was then in short supply.

The Yellowhead route, a map of which is reproduced in Fig. 1, was surveyed over the ground and from the air, and the route finally selected is not only the shortest, with 718 miles of main line, but also provides minimum elevation and maximum accessibility. The Yellowhead Pass is at an elevation above sea level of 3720ft, 720ft lower than Crows Nest, and 1400ft higher than Edmonton. The plateau south of Kamloops B.C., has an elevation of 3900ft, while the crossing of the Coast Range at Coquihalla Pass is at 3760ft. All but about 55 miles of the Yellowhead route parallels a transcontinental railway, and over the first 510 miles from Edmonton to Kamloops it follows the Canadian National Railway and, after crossing an open plateau for 55 miles, it follows the Canadian Pacific Railway for 67 miles, while the last 86 miles more or less follows the Canadian National Railway. The route traverses in turn 50 miles of wheatland, 200 miles of rolling timber country, 398 miles of mountainous terrain, and 70 miles of farmland.

Special hydraulic problems were encountered between Yellowhead and Kamloops, where the elevation drops 2600ft in 300 miles, and down the Coquihalla Pass, where it drops 3600ft in 30 miles. These hydraulic gradients are shown in Fig. 2. The route is not without its challenge to the operator, however, since it has seventy-two stream and river crossings ; while two 80-mile stretches along the railways, which have a snowfall between 30ft and 50ft each winter, have no roads worthy of the name. A large amount of paper work was required to obtain the necessary 60ft wide right-of-way, and easements were obtained from approximately 3000 landowners, while about fifty-six highway crossings and twenty-four crossings of the two railways each presented special problems. Saleable timber on the right-of-way was valued by appraisers for sale or other disposal.

At the outset two alternative diameters of pipe, 20in and 24in, were considered for the line, and the first decision was to construct a 24in line with two pumping stations, at Edmonton and Kamloops, to provide an initial capacity of 75,000 barrels daily. With the discovery of new oilfields, it was later decided to include a third pumping station at Edson to handle 120,000 barrels daily, and also, early in 1953, a fourth station at Black Pool, which came into operation in December last. Redwater crude oil, which is a 35-gravity crude with a viscosity of 115 seconds Saybolt at 40 deg. Fah, was selected as a basis for the hydraulic design of the line. An equation was used for computing friction loss, in which the value of f was checked with experience recorded on large-diameter pipelines, and the theoretical losses thus calculated were later checked against experience with the Interprovincial pipeline, and found to be conservative.

The design finally developed was based on the use of six stations to deliver 200,000 barrels daily. Their locations were selected with different delivery pressures to take advantage of local differences in elevation and, through use of tapered sections between stations, to obtain a minimum total pipe tonnage consistent with a minimum wall thickness of $\frac{7}{16}$in in the mountains and $\frac{1}{4}$in east of Jasper Park and in the Fraser Valley. The line pile used was made from 52,000 lb per square inch open-hearth steel, electric fusion welded, hydraulically expanded, tested in accordance with A.P.I. Specification 5LX, and having the following chemical composition :—0·30 per cent maximum carbon, 0·75 to 1·25 per cent manganese, 0·045 per cent maximum phosphorus, 0·05 per cent maximum sulphur. In the design the upper value of transverse yield strength was limited to 75,000 lb per square inch in order to avoid special welding problems in the field. The maximum allowable design working pressure was based on 65 per cent of the nominal yield strength, which is 52,000 lb per square inch for $\frac{1}{4}$in pipe and thinner, and 48,000 lb or 46,000 lb per square inch for heavier pipe, with a 10 per cent minus tolerance on nominal wall thickness.

The pipe is buried throughout the route to safeguard it against damage by landslides and snowslides, and also for insulating the oil against low temperatures which would cause the deposit of excessive wax in the line. There is one exposed span and that is where a narrow deep canyon made a buried crossing impracticable. The only expansion provisions are slack loops placed in the line when it was lowered into the trench. The normal cover is 30in, but it was reduced to 24in in rocky areas, while on the prairie, where severe winter temperatures are common, a 36in cover was provided. Corrosion was considered a minor problem, particularly on the western slopes, but the line was coated and wrapped throughout with coal tar primer, coal tar enamel, glass fibre, and impregnated felt.

When the project was first financed a sum of about 80,000,000 dollars was raised to cover the estimated cost of a two-station line of 75,000 barrels daily capacity extending from a then-proposed terminal at Acheson, Alberta, to the terminal at Burnaby, B.C. Later it was decided to begin the line 19 miles further east at East Edmonton, Alberta, to raise the daily capacity to 150,000 barrels by adding two pumping stations and increasing the number of pumps in the original stations and also the number of tanks in the two terminals ; to build a marine loading dock in Vancouver Harbour ; and to build a spur line from Sumas Junction to the International Boundary. These items increased the total estimated cost to 93,000,000 dollars, and a review of actual costs indicated that the work originally projected came within the original estimates.

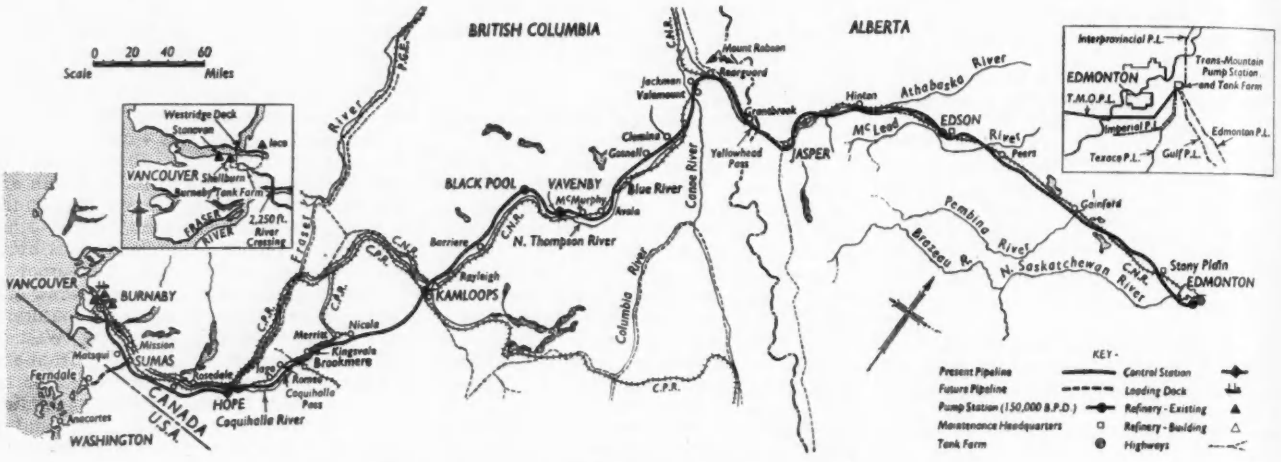


Fig. 1—Trans-Mountain Oil Pipeline from Edmonton to Vancouver

Line Construction and Equipment

The majority of the main line surveying was completed in September, 1951, and on March 31, 1952, the first sixteen carloads of pipe were delivered. A tentative construction schedule called for approximately 300 miles of completed pipeline in 1952 : four pipelaying teams were to work, the first starting near Vavenby, B.C., and working east towards Blue River ; two starting at Grantbrook, B.C., one working east and the other west ; and a fourth starting at Cheam Lake, B.C., and working west. Construction work actually started on February 27th. Pipelaying operations are shown in Figs. 3 and 4, which illustrate work proceeding at Vavenby and the Coquihalla Canyon respectively. The original schedule was revised several times through the 1952 season to suit supply conditions, and in April a fifth team was started to work eastward from Acheson, Alberta, and lay the 19 miles to the Edmonton terminal. In 1952 the entire 718 miles of the main line were located, and legal surveys were completed on all but 8 miles, while easements over 485 miles of right-of-way were acquired. A total of 329 miles of pipeline were laid, including fifty-six highway and twenty-four railroad crossings and fifty river crossings, the major rivers crossed being the Athabaska, Saskatchewan, Pembina, and McLeod rivers.

The 2250ft Fraser River crossing at Port Mann was extremely difficult because of tides, surface traffic and unfavourable weather. Two sets of welded pipe were prepared for movement to the channel by dollies mounted on a narrow-gauge railway, and two winches, each with a straight pull of 250 tons, were placed on the south shore and completed the pull in two days.

The locations of the four pump stations are "Edmonton," 6 miles east of Edmonton ; "Edson," 9 miles west of Edson, Alberta ; "Black Pool," 70 miles north of Kamloops; and

"Kamloops," 4 miles west of Kamloops. All the main station pump houses are 140ft long by 65ft wide, and are of similar design, having rigid steel frames, corrugated gable roofs and concrete block sides, with a light green stucco exterior finish. Interior wall finish is light buff "Kolorbord" and the ceilings are of Johns-Manville steel pan acoustic tile laid over 2in fibre glass batts. Each pump house contains an engine, pump, boiler and control room, a fuel preparation room, a storeroom and a washroom. The engine and pump rooms, built to house four main pumping units for 200,000 barrels daily capacity, are separated by a vapour lock concrete block fire wall, and both are provided wth overhead cranes. Each station has also a 50ft by 30ft auxiliary building containing a fire pump room, a three-bay garage and small heater room.

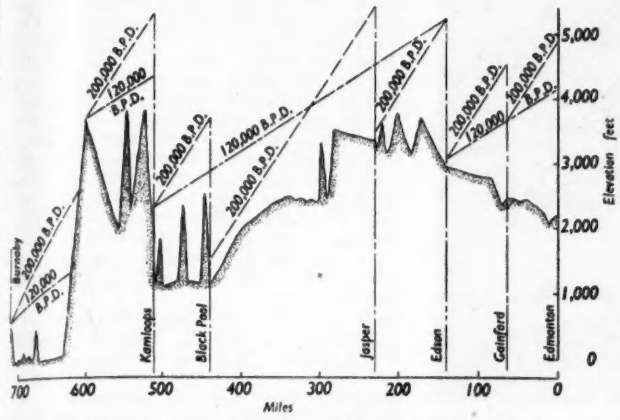


Fig. 2—Profile and Hydraulic Gradient, 200,000 and 120,000 Barrels per Day

All stations, one of which is illustrated in Fig. 5, are equipped with Nordberg diesel engines driving Bingham centrifugal pumps through Dominion Engineering speed increasing gearing. The Edmonton station is equipped for parallel pump operation, and has three Mark SSG-138-HFG, dual fuel, "Supair-Thermo" supercharged, eight-cylinder, 1760 h.p., 500 r.p.m. engines, operating principally on natural gas. These are direct coupled to Mark SI 30-20 speed increasing gears having a 1·0 to 7·6 ratio. A pedestal bearing is installed between the engine and the fire wall, and the gear units are direct coupled to 8×10 WSB five-stage centrifugal pumps. The main units at Kamloops station are similar except that the engines are equipped to burn liquid fuel only, and the Black Pool station, completed in December, 1953, is similarly equipped. Edson station is equipped for series pump operation, and has three Mark FS-136-HSC, "Supair-Thermo" supercharged, six-cylinder, 1320 h.p., 500 r.p.m. engines, direct coupled through the fire wall to Mark SI-30-16B speed increasing gears having a 1·0 to 8·2 ratio, which in turn are coupled to 10×12 HSB centrifugal pumps. Future stations at Gainford and Jasper, to accommodate 200,000 barrels daily throughput, will be similarly equipped for series pump operation.

With one unit each operating at Edmonton and Kamloops, the line has a capacity of 75,000 barrels daily, and this may be increased to 120,000 barrels daily by operating two units each at Edmonton, Edson and Kamloops. To increase the capacity to 150,000 barrels daily two units operating at each of the four stations, including Black Pool, are required. The third units at each station are standby sets. Consideration was given to the comparative merits of parallel and series arrangements of the station pumping units, and it was decided that the parallel arrangement was more economical for the high static head conditions encountered at Edmonton, Black Pool and Kamloops, while the series arrangement was more suitable for Edson, Gainford and Jasper. For example, with a throughput of 120,000 barrels daily the static lift will be about 45 per cent of the total pumping head at Edmonton, and 65 per cent at Kamloops. Under such conditions parallel unit operation is of advantage because flows up to 75,000 barrels daily can be handled by the operation of a single unit, while if series units had been installed two of them would have to be operated at reduced speeds and greatly reduced fuel efficiency. The actual throughput demand could not be predicted closely, and it was economical to install station equipment in rather large increments; thus the parallel pumping units at the high static lift stations offered the most economical and flexible arrangement.

Although the line flow can be manually controlled with the station tanks floating on the line, three kinds of automatic engine control devices are being provided at the stations. One group, sensed by unit flow meters, will distribute the load equally between the parallel pumping units; another group will maintain station intake and discharge rates in synchronism and a third group, including Foxboro "Tivy Boxes," will permit automatic placing or substitution of pumping units into service. Crude oil for engine fuel is drawn off the main line and passes through a settling tank and heater into a Sharples centrifuge and then to a pure fuel engine supply tank, which is in the fuel preparation room and kept at normal temperature.

At Edmonton the diesels operate as dual-fuel engines, using 5 per cent liquid fuel and 95 per cent fuel gas, which is received through a regulator at 60 lb per square inch, and at this pressure it passes through a scrubber to the fuel gas header. At each engine it then flows through a low-pressure supply regulator and a Fulton Sylphon safety shut-off valve controlled by engine fuel oil pressure. Each station has about thirty electric motors driving auxiliary equipment. The power supply at Edmonton and Kamloops is purchased from the local public service companies and engine driven generator sets have been installed at both stations as standby sets. The Caterpillar engine at Edmonton is equipped to operate on natural gas, and that at Kamloops on diesel fuel. Electric power at the Edson and Black Pool stations is provided by two slow-speed crude oil-burning diesel-driven units, one carrying the load, the other serving as a standby. The Edson engines are of Dominion Engineering Company's manufacture, and those at Black Pool are of Cooper-Bessemer design.

Each station has two heating systems, consisting of forced circulation hot water heating in the main pump house, and gravity return steam heating in the combination garage and fire pump house. The water in the pump house system is heated either by exhaust silencer waste heat boilers or auxiliary crude oil-fired boilers of 1,000,000 B.Th.U. per hour capacity. Two of the Nordberg engines operating near full load will generate sufficient heat for the waste heat boilers, which are automatic in operation, to warm the pump house in the coldest weather. However, under light engine loads in cold weather the oil-fired boiler, manually started, operates automatically with an induced draught fan working through a time relay. The steam for each auxiliary building is generated in a diesel oil-fired boiler operating at 2 lb per square inch under automatic electric control.

The first pressure limiting station is located at Vavenby, which is 165 miles west of and 2100ft lower than the Yellowhead Pass, where an automatic valve will shut to ensure that the static head downstream to the Thompson River crossing at Kamloops, elevation 1120ft, shall be reduced by 650ft to a safe head of 2160ft. The other pressure relief station is located at Hope, elevation 210ft, which is about 30 miles west of the 3760ft summit of Coquihalla Pass. Here a battery of relief valves can spill oil into two 50,000-barrel capacity tanks so that the pressure in the pipe from Hope to Burnaby may be reduced to safe limits in case of accidental closure of a valve against the main line flow. The use of this pressure-limiting equipment saved about 5,000,000 dollars in the original cost by avoiding the need for heavier wall pipe to withstand high pressures during accidental shut-offs in the low sections of the system.

Communications

The installation of a microwave radio system was considered, but it was rejected as inadvisable for two reasons: first, because of high cost due to the tortuous route which would require too many repeater towers; and secondly, because maintenance was impracticable over two 80-mile stretches that receive 30ft to 50ft of snowfall each winter and have no roads. The communications facilities provided include: a telephone circuit consisting of a leased specially installed metallic pair approximately paralleling the pipeline from end to end and connecting about twenty-five locations; a leased teletype service

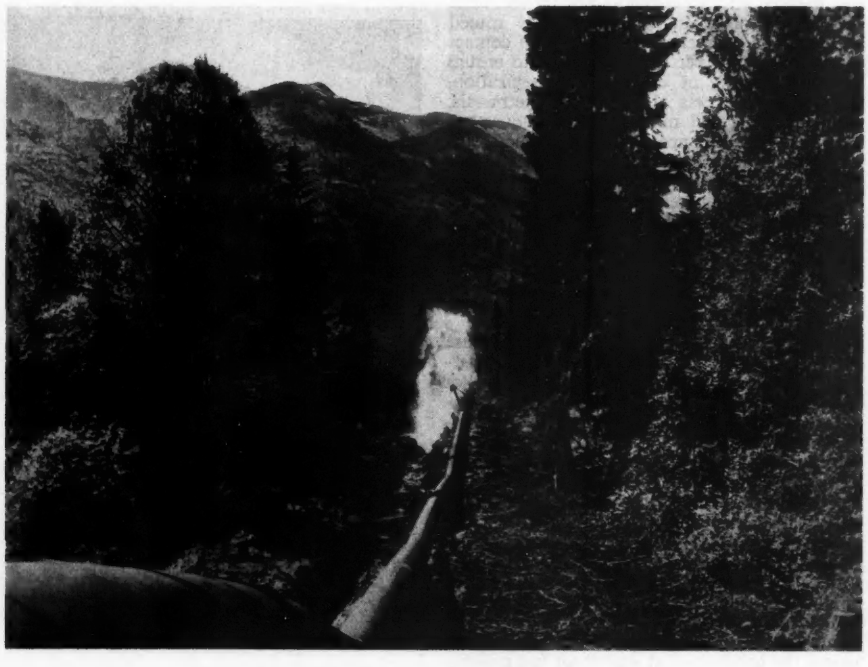


Fig. 3—Pipe-Laying near Vavenby

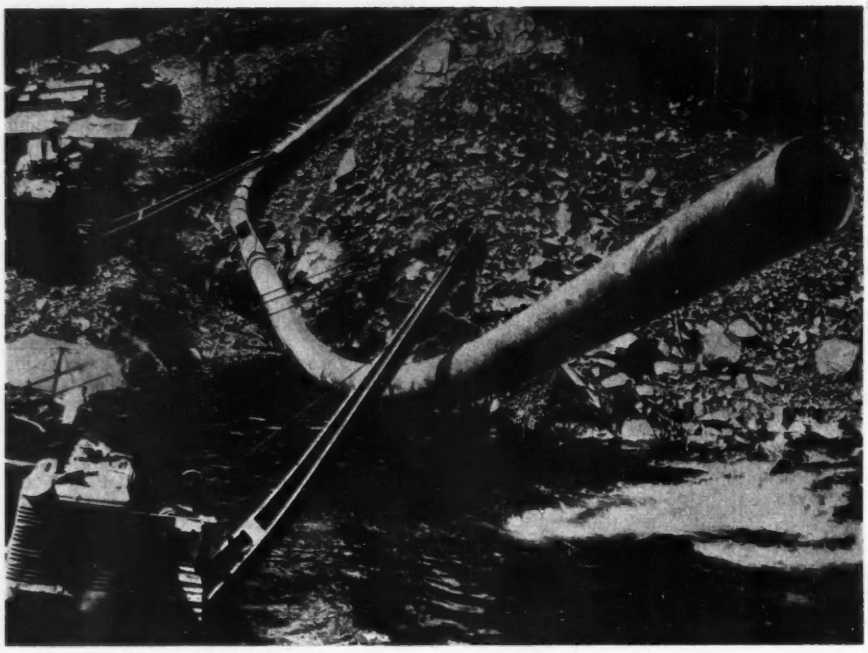


Fig. 4—Pipe-Laying in Coquihalla Canyon

connecting about seven locations; and dual-frequency radio facilities, including nine fixed stations and twenty-five mobile stations, each operating on 2628 kc/s A.M. and 165·63 Mc/s F.M.

The telephone circuit provided by Canadian National Telegraphs is primarily for dispatching purposes and connects all pump stations, terminals, maintenance headquarters and scraper traps, plus a number of emergency sets in pole-mounted boxes at convenient points. The metallic pair is marked on the cross arms to permit the use of portable clip-on telephones. The ringing of all regularly connected instruments from the dispatchers' office and from Edmonton station is to be made possible by installing an electronic tone-response ringing system. The teletype service, taken on a temporary basis to determine its need, connects the offices and pump stations only and is intended for administrative messages, but can be taken over by dispatchers if the telephone circuit fails. Although over much of the route the telephone and teletype circuits normally are on the same C.N.T. pole line, the teletype can be routed differently in emergencies. To maintain contact with maintenance personnel and also to ensure further continuity of dispatch communication, nine fixed radio sets are located at terminals, pumps stations and maintenance headquarters. The 2628 kc/s channel has been found surprisingly effective in piercing the mountainous terrain on a point-to-point basis and with a minimum of manual relaying. The v.h.f. channel is for normal communication with and between the trucks, cars and vehicles; however, these vehicles carry sets operating in both channels, and there are walkie-talkie sets, functioning on the v.h.f., for local contacts during crew operations.

The major oilfields in the Edmonton area are connected to the trans-mountain pipeline terminal, which is situated immediately west of Interprovincial Pipeline's terminal by five gathering and feeder pipelines of other carrier companies. The Edmonton terminal, situated in a 160-acre site and subject to rigorous winter weather, contains eight 150,000-barrel and four 80,000-barrel steel cone roof tanks. The western terminal at Burnaby, near Vancouver, is situated on a 200-acre site on Burnaby Mountain at an elevation of 495ft to 575ft above tidewater. This terminal in an area subject to milder winters, contains six 150,000-barrel and four 80,000-barrel steel floating roof tanks. The numbers and capacities of terminal tanks should permit the handling of at least three and possibly four grades of crude oil, and those scheduled for receipt as initial line-fill are designated as "Redwater," "Light Mix" and "Leduc."

The marine loading dock at Westridge, on Burrard Inlet, is fed by gravity flow from the Burnaby terminal through 2½ miles of 24in pipeline. Local pipelines have been privately constructed by Imperial Oil and Shell Oil to connect the tank manifold at Burnaby with the recently modernised and enlarged refineries on Burrard Inlet. The 12in line of the former company is 4½ miles long, including a 3500ft crossing under the Inlet, while the 10in line of the latter company is 2½ miles long, and both can deliver 50–60,000 barrels daily under gravity flow. The Standard Oil Company of British Columbia, Ltd., has proposed the modernisation and enlargement of its Stanovan refinery, also on Burrard Inlet, and the construction of a private pipeline to the Burnaby terminal. To receive line drainage in emergencies the intermediate pump stations are equipped with one or two 80,000-barrel capacity tanks, those at Edson having cone roofs and those at Black Pool and Kamloops having floating roofs. At North Kamloops, B.C., a take-off has been provided to service the new 5000 barrels per day refinery which is being erected there and is expected to go "on stream" shortly.

The loading dock at Westridge is L-shaped, the main pier being 275ft long and the dockhead 150ft long with 85ft walkway extensions at each end. Buoyed moorings are located 740ft apart and 80ft behind the face of the dockhead. The dock construction is of pressure-creosoted wood piling with timber caps, timber stringers and decking. As initially constructed in the 14-acre anchorage, the dock can accommodate one T2 tanker and some barges. The 24in line from Burnaby will deliver up to 20,000 barrels per hour by gravity, and a system of friction tubes in parallel is located on the shore for control of the flow rate. Adjacent on a 9-acre site are two 10,000-barrel cone roof tanks, for use in changing grades of oil in the delivery line, and a 50,000-barrel cone roof tank and a sump for ballast water skimming. There are also the usual oil transfer and ballast discharge lines, a fresh water line from shore, fire protection facilities, telephone communications and a floodlighting system.

Provision has been made for delivery of oil by spur pipeline to the 35,000-barrel per day plant of the General Petroleum Corporation, southwest of Ferndale, Washington, which is due for completion late this year. A 24in spur line is to be built from the main 24in line at Sumas Junction, about 70 miles east of Vancouver, to the International Boundary, and will be extended 15 miles to Laurel, Washington, with a 16in lateral 11 miles to the Ferndale plant. Sufficient static head exists on the line from Coquihalla pass, elevation 3760ft, to gravitate oil at a 200,000-barrel daily rate as far as the Seattle area; thus making installation of break-out tanks at Sumas Junction unnecessary.

Pressure Testing of Pipeline

An essential phase of the construction work was the pressure testing of the main line prior to introduction of the oil. The Trans-Rockies route is subject to the vagaries of prairie foothill, mountain fall and winter weather, and unpredictable freezing conditions. When it seemed that construction would not be finished before the 1952–53 winter set in, it was decided to pressure-test the line with compressed air, but when completion by September, 1953, was assured it was decided to pressure-test the line with water.

It was arranged that the testing should be done in eighteen sections, each being subjected for

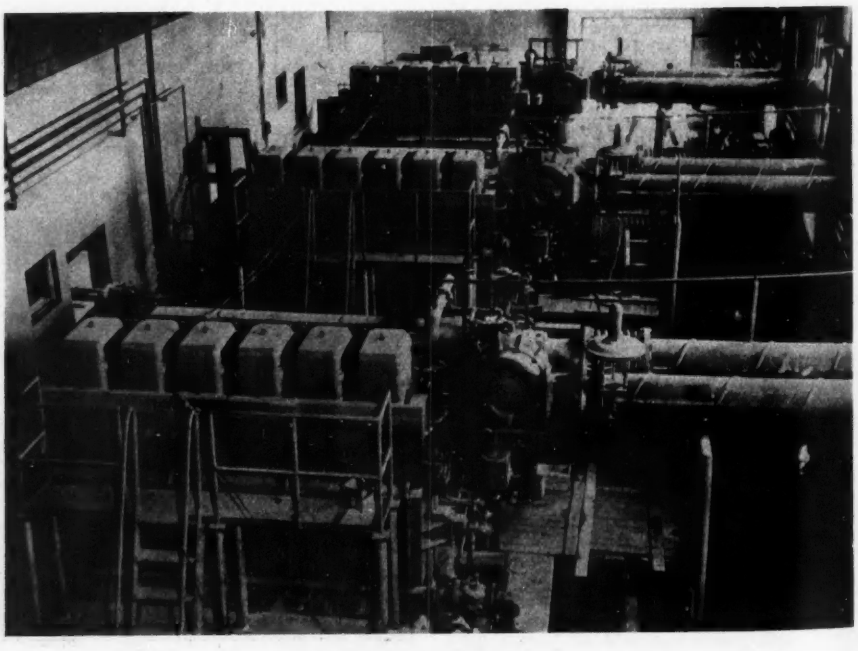


Fig. 5—Pumping Station

twelve hours to a hydrostatic pressure equal to 125 per cent of that normally attained during pumping operations. Seven portable pumping units were purchased, these consisting of "Gaso" 10in horizontal duplex piston power pumps, belt driven by Waukesha Model 6WAKU petrol engines. Five medium-pressure units in parallel could fill the line with water at about 85,000 barrels daily, a rate which moved the scrapers along at about 1¼ miles per hour, and by careful planning it was possible to fill most of the line with water from three sources, namely the North Saskatchewan and Blue rivers and Yellowhead Lake. The station pumping units were given a trial run during these tests. The water to fill about 200 miles of pipeline from Edmonton west was the same as that used to test the Edmonton Terminal steel tanks, and was drawn from the tanks and moved up the pipeline by the Edmonton station pumps. Through use of the station tanks as float tanks, the pumps at Kamloops station were operated in series with the portable "Gaso" pumps, grouped about 145 miles distant, to boost the water from the Blue River south-west over the plateau to Merritt and over the Coquihalla Summit.

After each section was filled with water the pressure was raised to the prescribed test limit by a high-pressure Gaso Waukesha unit, and the availability of two such units permitted testing simultaneously in two areas. The highest pressure required was in the section just south of Kamloops station, which was tested to 1425 lb per square inch.

The finding of small leaks during the water test presented a problem in way of sandy terrain where small stream crossings were frequent and where access and travel were difficult. In this connection the four Fisher M-Scope sonic leak detectors, which operate on the principle of amplifying the high-pitched noises of the escaping water, proved especially useful. One leak, amounting to 12 to 15 barrels per hour, which occurred in a roadless 28-mile section above Blue River, where surface water run-off and rain are prevalent, took exactly three weeks to find, since general rain prevented effective use of the detectors. Detection by a non-toxic fluorescent dye was attempted, but proved futile. Eventually the leak was isolated in a 6-mile portion, and with better weather and an "M-Scope" equipped with an improvised super-amplifier, the leak was found on the bottom of the pipe in sandy soil at the highest point in the 28-mile section, where the internal pressure was lowest.

Because of the waxy nature of the Alberta crude oils, and the tendency of such wax to congeal and adhere to the pipe wall, especially during winter temperatures, it is necessary to run scrapers through the line at intervals of about five to seven days, the scrapers being taken from "scraper traps" located 75 to 110 miles apart along the line.

A difficult problem in the field is the transport of personnel and heavy equipment, since Western Canada's main road systems do not cross the Rockies and the Cascade Range via the trans-mountain route, although improved roads are accessible for a total of 370 miles. About 165 miles of line are near seasonably fair roads ; about 75 miles are in sections where roads are impassable in winter, and about 110 miles have practically no roads. Snow to a depth of 30ft to 50ft falls annually in these two sections, and travel even over the 235 miles of good road from Edmonton to Jasper is precarious during much of the winter, truck travel being restricted during the spring thawing periods. About 600 miles of the route are generally paralleled by the Canadian National Railway. However, the passenger service is practically on a once-daily basis. The Canadian Pacific Railway operates over the Coquihalla Pass route, but this line is frequently immobilised during two or three months of winter by heavy snowfall. Airline service in the West is excellent, but is available to the pipeline only between Vancouver and Edmonton and between Vancouver and Kamloops.

Because of the foregoing conditions all the maintenance crews are equipped with a variety of four-wheel-drive vehicles, and experience on snow-covered roads will be gained this winter by the trial operation of "snowmobiles," "snowcats" and "muskeg crawlers." Certain crews are equipped with "D-6" or "D-7" Caterpillar tractors, which are transported on heavy-duty trailers over the passable roads, while for movement into otherwise inaccessible areas three railway units, each consisting of a heavy-duty flat car and a combination sleeping and boarding car, have been obtained.

High-Speed Passenger Launch

THE high-speed passenger launch shown in our illustration has been completed recently by Vosper, Ltd., to meet the specifications of Shell Tankers, Ltd., for use by the Compania Shell de Venezuelos, Ltd. The launch, which had to have good sea-keeping qualities, is designed to transport twenty passengers and accompanying gear to the oil rigs, located some 20 and more miles off the shore of Lake Maracaibo, at a speed of 18 knots. Although the probable speed/length ratio was in the transition range between round and hard chine forms a round bilge form was adopted after a series of model tests and the following are principal dimensions of the craft as built : length overall 53ft, length on water line 50ft, breadth moulded 13ft 6in, draught aft 3ft 11in.

The hull, which is constructed of mild steel, is of mixed welded and riveted construction, the shell plating consisting of galvanised plate ⅛in and ¼in in thickness. All three watertight bulkheads have steel boundary bars and steel plating up to the water line with aluminium alloy plating above this level to the deck. Aluminium alloy has been used for the deck beams and plating, the latter being of "hobnail" non-slip pattern, and also for the superstructures, cabin flat and engine-room flooring. A 4in diameter rubber fender extends completely around the craft at deck level and vertically at the transom and in addition a hollow half-round steel section is welded to the steel shell at a level half way between deck and water line, from stem to transom.

The hull is divided into four compartments consisting of the fore peak, passenger cabin, engine-room and aft peak. Aft of the fore peak, which is arranged as a cable locker and sheathed with pine in way of the chain stowage, is the cabin, which provides seats for twenty passengers. The seats, of double bus pattern framed in tubular steel and upholstered with rubber foam covered with "Vynide," are mounted on raised platforms at the sides to enable the passengers to see through the windows when seated. An emergency escape hatch is provided in the cabin roof forward to port and life-belts are stowed in built-in lockers under the side deck.

A short ladder leads from the cabin to the wheelhouse, which is not fully enclosed and in which all the engine controls and the steering wheel are arranged to port. Electric-hydraulic windscreen wipers are fitted to the port and starboard front windows of the wheelhouse, the sides of which are extended aft to form a coaming. There is a hinged aluminium alloy table and at the aft end of the wheelhouse are two double bus pattern seats under the canopy roof upon which are mounted two searchlights. Clear of the wheelhouse space are two raised trunks, one to port and one to starboard, the latter being fitted with a hatch so as to give access to the engine-room. A circular hatch provides access to the aft peak space, which is fitted with chocks for the stowage of deck equipment and also houses the steering gear which controls twin mild steel spade rudders mounted in line with the wing propellers.

Fresh water supplies are carried in a 10 gallons capacity tank placed under the cabin flat, and for clearing the bilges in the passenger cabin, engine-room and aft peak, suction lines are connected to a power pump, driven by the auxiliary, and also to a hand-operated semi-rotary pump located just aft of the helmsman's seat. Ventilation of the various spaces is mainly by natural means, two mushroom ventilators each serving the fore and after peaks and two mushroom and two cowl ventilators supplying air to the cabin. Four cowl ventilators mounted on the wheelhouse roof supply air to the engine-room and fumes are extracted from the bilge and battery compartment by means of an electric fan.

The launch is propelled by three Rolls-Royce Mark C.6S.F.L.M., six-cylinder in-line, four-stroke, supercharged oil engines fitted with twin-disc reverse gears, giving a reduction of 1·96 to 1. All the units, which are rated to develop 200 b.h.p. at 1800 r.p.m., are fresh water cooled and arranged for electric starting. The wing engines drive right-hand propellers while the centre line unit is located aft and drives a right-hand propeller through a 1 to 1 vee return drive. Single strut mild steel fabricated shaft brackets fitted with cutless rubber bearings support the propeller shafts, which carry three-bladed manganese bronze propellers. A total of 260 gallons of fuel are carried in two tanks which are stowed under the cabin flat and the auxiliary set consists of a 3 b.h.p. Stuart Turner diesel engine driving a 1·5kW generator and also, through a clutch, a 900 gallons per hour bilge pump.

On trials the launch achieved a speed of 19·75 knots and a turning circle having a diameter of between four to five boat lengths at full speed and completed in fifty-five seconds. From full speed ahead the launch can be stopped in fifteen seconds without the use of reverse gears and stability tests showed that the boat had a metacentric height in excess of 3ft.

High-Speed Passenger Launch

Insulated Food Container Factory

UNDER the Government school meals scheme large numbers of insulated containers are used for the distribution of food cooked in central kitchens to individual schools. Four types of these containers are used—one rectangular and three cylindrical—and the containers are fitted with trays from which the cooked food is served direct. An order for the supply of rectangular containers was placed with Grundy (Teddington), Ltd., of Somerset Road, Teddington, Middlesex, in 1948, and although it was only for a relatively small quantity the firm decided to tool up for semi-line production to reduce manufacturing costs and improve the quality of the containers. Since that time the firm has received a steady stream of orders and we are informed that to date it has made no less than 400,000 containers.

As this kind of container is designed for the transport of cooked food with the minimum loss of heat, they are not only suitable for the distribution of school meals, but also for taking food from central kitchens to large work sites where individual canteen facilities are not available. They are relatively light and easy to clean, being constructed throughout of aluminium except for their catches, pins and handles, which are of cadmium-plated steel.

Each container is of double skin construction, the space between the skins being packed with granulated cork and hermetically sealed by welding round the edges. An efficient seal is of particular importance to prevent the penetration of water between the skins during cleaning which would destroy the sterile conditions and insulation value of the cork. For this reason each container is tested after assembly in a tank of water heated to 195 deg. Fah. for five minutes and any fault in the sealing weld is revealed by air bubbles. In the early designs of containers the hinges and catch plates were riveted to the outer shell, but trouble was experienced with insulation owing to the rivet holes pulling in service. This problem was solved by the makers introducing a quicker and completely effective method of attaching the steel plates to the aluminium skins of the containers. Aluminium studs are now inserted and expanded in holes drilled in the steel plates and these studs are welded to the aluminium skins on a spot welder.

A large shop at the works of Grundy (Teddington), Ltd., is now equipped for the production of some 700 rectangular and 2000 cylindrical containers a week. We recently took advantage of an invitation to visit the works and see the container production shop, some views of which are reproduced on this page. The nature of the work calls for a fair amount of hand labour and by the introduction of simple jigs and fixtures the operations have been suited for readily trained semi- and unskilled labour. The use of good tooling and specially developed machines also plays an important part in speeding assembly by giving complete interchangeability of component units. The production of both the rectangular and the cylindrical containers follow generally similar lines.

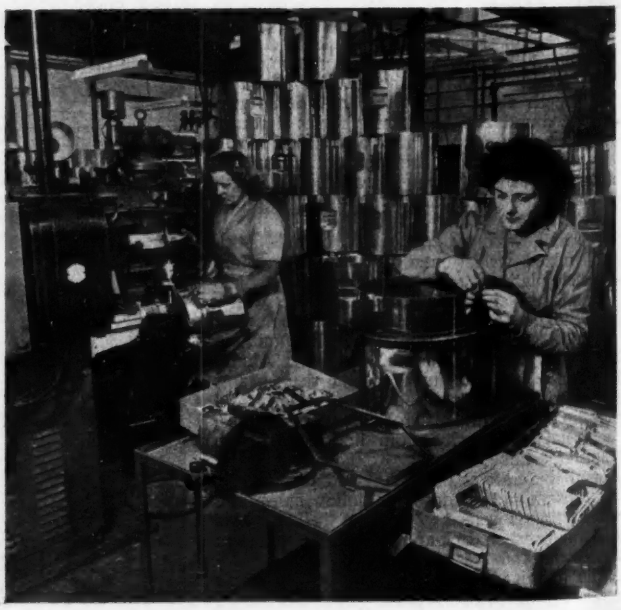
Aluminium sheet is delivered into one corner of the shop at the end of a machine line on which the initial operations are performed. The outer casing of 16 gauge sheet is first guillotined to size and flanged on the closing edges on a brake press. The sheets for the rectangular containers are then transferred to a press and formed to box shape with a hardwood tool, and the cylindrical containers are rolled into cylinders on a set of rolls.

The longitudinal closing seam is welded on an automatic continuous welding machine shown in one of our illustrations. This machine was designed and built by the firm and it is adaptable for welding the inner and outer shells of both types of container. Shells are fed by hand into one end of the machine, where they are picked up by a series of feed rollers driven at a predetermined speed. Rollers hold the flanges together as they first pass under a rotating wire cleaning brush, and then under an "Argonarc" welding head. Welding is thus carried out continuously at a controlled rate as the shells are fed into one end of the machine and removed from the opposite end. As a stock of shells is maintained in the shop some days may elapse between the forming and the seal welding operations. For this reason and to ensure that the flanges are quite clean for welding the machine to be seen at the side of the continuous welder was developed. It is fed continuously from one end and during the passage of each shell a light cut is milled off the top of the mating edges of the flange. As the shell then passes straight to the welder danger of contamination of the edges which might lead to faulty welds is reduced to a minimum.

The handle recesses are then pressed in the outer shells and the hinge and catch plates are stud welded on. For this work simple location plates and jigs are used to register the parts in

Rectangular Container Shell Making Section

Continuous "Argonarc" Seam Welding Machine



Spot Welding Catch Bodies to Cylindrical Containers

position. A typical example of the lightweight simple jig used for this class of work can be seen in the photograph we reproduce of the operator spot welding catch bodies to a container. In the case of the rectangular containers aluminium rubbing strips are spot welded on each side before the hinges and catch plates are attached.

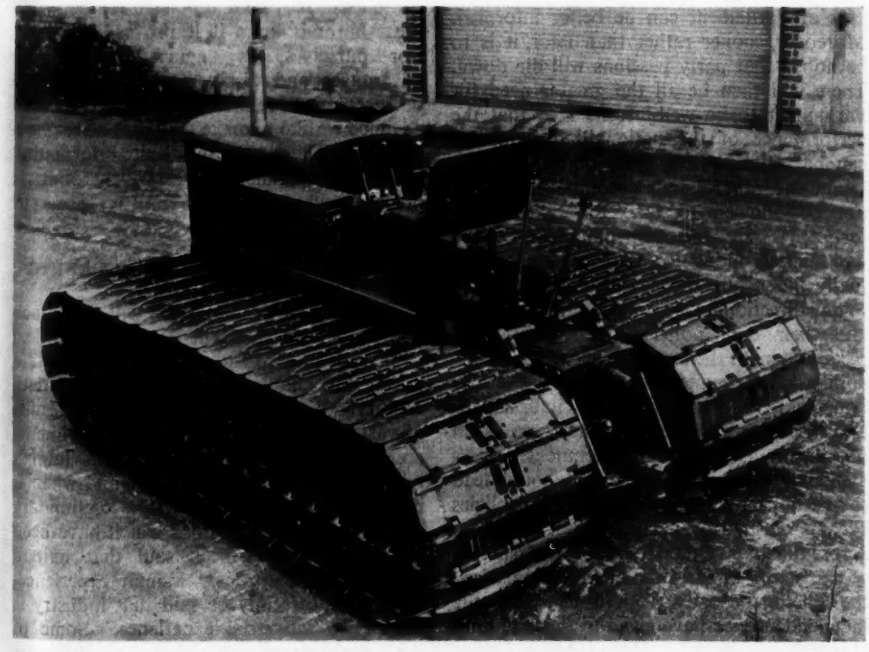
The inner shells have flanges formed upon their upper ends and these flanges form a press fit into the outer cases. When the inner and outer shells have been assembled and the space between filled with granulated cork, the bottoms of the containers are pressed in and the top and bottom seams are acetylene gas welded by hand operators using 99 per cent pure aluminium rod.

The lids of the containers are made up of two dished pressings which have cork insulation between and are assembled by gas welding. The food trays and their lids are aluminium pressings and their handles and catches are attached by spot welding.

As the containers are in constant use and are liable to receive rough handling, the firm has arranged a comprehensive maintenance and repair service. As part of this service a well-equipped travelling repair workshop visits the centres using the containers at regular intervals to carry out repairs on site.

Tractor for Peat Bog Reclamation

A WIDE gauge track tractor has recently been tried out at Gowla Bog, in Eire, where the Irish Sugar Company has an extensive scheme of peat bog reclamation in hand. It has been estimated that there are between 2,500,000 and 3,000,000 acres of peat bog in the Irish Republic, and it has been stated that "wet bog" has a water content of 94 per cent or more, the water content of "dry bog" being put at 88 per cent Furthermore, it has been found that the decaying fibrous matter in a bog can be compressed to one-twentieth its natural state by removing the water. The principal problem, therefore, in designing a crawler tractor which would be suitable for such conditions was weight distribution, combined with the provision of tractive power over a virtually non-existent surface. The "Platypus 30" tractor has been adapted for the work, the result being a wide gauge machine with 54in track centres and 32in track plates. The tracks extend to over 9ft and the ground pressure is less than 1·3 lb per square inch. This version of the tractor, which is illustrated herewith, is known as the "Platypus 30 Bogmaster," and it is a product of Rotary Hoes, Ltd., Horndon, Essex. The engine is a Perkins "P4" diesel, developing 30 b.h.p. at 2000 r.p.m., and the transmission is through a 12in single dry-plate clutch to a gearbox giving six forward and two reverse speeds. Basically, the new "Bogmaster" is similar to the "Platypus 30" crawler tractor described in THE ENGINEER of December 12, 1952.



Tractor for Peat Bog Reclamation

Capacitor Control Relay

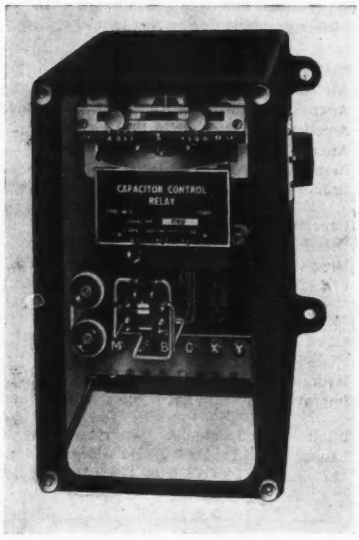
WE illustrate a relay developed and produced by Ferranti, Ltd., Hollinwood, Lancs, for the automatic switching of capacitors installed for power factor correction. It provides single-stage control of power factor by ensuring that the associated capacitor is switched when the reactive kVA reaches a preset value, which can be varied over wide limits.

The main element of the instrument consists of an induction disc wattmetric relay with its current and voltage windings arranged so as to make it responsive to the reactive component of the volt-amperes in the load circuit. The disc, which is of copper, is spring controlled and has a contact arm attached to it. When the load is at unity power factor the disc remains stationary with the contact arm in a central position. If the power factor becomes less than unity the disc and its contact arm move to the right when the power factor is lagging and to the left when it is leading. Associated with the moving contact are two "fixed" contacts, one on each side of the central position.

The position of these "fixed" contacts can be varied to obtain different settings, the setting values being dependent on the distance through which the disc has to travel before the moving contact touches one of the fixed contacts. The "lead" and "lag" contacts are independently adjustable over a calibrated scale of 4 to 16 per cent of the total reactive volt-amperes corresponding to the rated primary current of the current transformer and the supply voltage. Each contact is carried on a block of insulating material which slides smoothly along a metal plate and which can be clamped in any desired position by a knurled nut.

To extend the range of settings, tappings from the current coil are brought to a plug board with three plug positions. The actual settings are then determined by multiplying the percentage settings by the plug board constants 1, 2 or 5 and the total range covered by each contact is, therefore, 4 per cent to 80 per cent.

An auxiliary relay is fitted below the main induction element and is energised by the closing of the "lag" contacts. Substantial contacts on the auxiliary relay then close the external circuit to the heavy-duty capacitor contactor. The auxiliary relay is also provided with "hold-on" contacts which keep it energised until the power factor changes sufficiently to close the "lead" contacts. When this takes place the operating coil of the auxiliary relay becomes de-energised and the relay is reset, thus opening its main contacts and causing the capacitor to be disconnected. A resistance in series with the relay coil limits the current during resetting.



Capacitor Control Relay

A small transformer is fitted in the back of the case to step down the supply voltage to 100V for the auxiliary relay coil circuit. To avoid the possible effects of vibration the 100V a.c. supply is passed through a metal rectifier and the auxiliary relay is operated by direct current. Two fuses are fitted in an easily accessible position inside the case; they are rewireable and are connected in the main voltage supply. A rotary selector switch is mounted on the side of the case to give automatic or manual control of the capacitor as required.

The "lead" and "lag" contacts associated with the induction element are protected by the hold-on contacts of the auxiliary relay, the low voltage from the incorporated transformer and the use of a metal rectifier to feed the auxiliary relay coil. The burden imposed on the current transformer does not exceed 1·5VA.

The case measures 11in by 9in by 9in and is of cast aluminium with black stove enamel finish. The cover is white enamelled on the inside and has a full glass window giving an unrestricted view of the working parts. Access to the relay is obtained by removing the cover, which is held by four knurled nuts. Provision is made for sealing.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

PACKAGING CODE: USE OF DESICCANTS IN PACKAGING

No. 1133, Sec. 19 : 1953. Price 3s. The deterioration of the contents of packages is of concern to all packers, but in particular to exporters. Metal goods are liable to corrode in damp and humid climates, and materials such as textiles, leather and paper are subject to other forms of deterioration. Some articles can be given protective treatment during manufacture, and others can be protected by the application of corrosion preventives, and by other means. Some, however, such as delicate instruments, cannot be given any such treatment, and for these it is essential to ensure that the humidity within the package remains reasonably constant. The kind of packing which achieves this is known as a desiccated package, and this method is dealt with fully in this new publication. The section describes the method, deals with factors governing the choice of desiccant, the determination of the quantity needed and other general packaging considerations. The new section completes that part of the Packaging Code which deals with protection of contents against deterioration.

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NATIONALISED INDUSTRIES AND PARLIAMENT

When, under the Labour Government, a number of industries were nationalised little attention was given to the way in which those industries were to be made accountable for their actions to Parliament and to the public at large, as distinct from a Minister representing the Government of the day. That inattention, it may be suspected, was neither wholly accidental nor wholly deliberate. If the industries were to be nationalised at all then the main matter demanding consideration at that time was how best it was to be done. The first tasks had to be those of fixing what were to be the powers of Boards, Commissions and the like and what were to be the powers of Ministers, acting for the Government. How to make the industries, once nationalised, better accountable to Parliament and public was something that could be and was in fact left over for further consideration. Experience has now been gained. It has shown, in our view conclusively, that some closer relationship between the industries concerned and Parliament is very desirable. It is needed because, though they are subject to broad Ministerial direction, the nationalised industries are still monopolies lacking the salutary checks provided by competition. Those industries need, therefore, not only to be in fact efficiently operated but to be manifestly seen to be efficiently run, if those they serve are to feel satisfied about their activities, and to refrain from carping and irresponsible, as opposed to really constructive, criticism. Moreover, since one of the objects of nationalising the industries was to ensure that they operated to the advantage of the State their policies ought to be widely publicised and understood so that comment upon them can be properly informed and questions about them be adequately framed. By what means Parliament might keep itself informed on these matters has now been under examination for many months by a Select Committee under the chairmanship of Mr. Assheton, and last Monday a report of that Committee, (upon which we commented in our issue of August 21st last year) was debated in the House of Commons.

The problem set before the Assheton Committee was no easy one to solve. For two opposite dangers have to be evaded. On the one hand accountability to Parliament and through Parliament to industry and the public must not be so slight that there will be little or no real check upon the efficiency of a nationalised industry and the desirability of the policies it is pursuing. Maybe that is not a very serious danger at present. So long as the nationalised industries remain subjects for party political debate there is certain to be plenty of enlivening criticism ! Much of it, however, is likely to be misdirected or based upon misapprehensions unless at least some Members of Parliament can be better informed. Moreover, sooner rather than later, it is to be hoped that party passions will die down. There will then be all the greater need for Parliament to be well-informed so that the performance of the nationalised industries can be watched in a more objective spirit. Upon the other hand, accountability must not be allowed to take too extreme a form. Wisely the controlling bodies of nationalised industries were set up as virtually independent concerns, free from day to day direction by a Minister, able to formulate their own policies, take commercial risks, and make their own decisions. Answerability to Parliament would be too dearly bought if the accounts of nationalised industries were subject to the same kind of scrutiny as those of Government departments, if their slightest actions could lead to questions in the House, and if their policies became decided by party political argument across the floor of the House. Mr. Assheton, at a meeting of his Committee, summarised the dilemma neatly. " We feel that the independence we have given to those nationalised industries . . . should be as far as possible . . . upheld, and yet we feel that our duty to the public . . . demands that we should satisfy ourselves that those industries are being managed efficiently." How is that dilemma to be resolved ?

Judging by Mr. Crookshank's speech in opening Monday's debate the Government is thinking, in consonance with the recommendations of the report of Mr. Assheton's committee, of setting up a small select committee of the House to maintain continuous contact with nationalised industries. Again in consonance with that report it is regarded as essential that the new body shall " set up a tradition of conduct which will result in its being regarded by the Board not as an enemy, or a critic, but . . . as a guardian of the public interest," a confidant, and a protection against irresponsible pressure. In fact, when the proposal is further examined, it seems very unlikely that the suggested committee could possibly be regarded " as an enemy." For the functions of the committee, as contemplated by the Government, seem so limited that no Board could possibly feel much trepidation about its enquiries. The committee would be served by a clerk from the committee office and not by an officer from the department of the Auditor-General, so that no detailed examination of accounts would be possible ; it would be barred from enquiry into future policy, presumably on the ground that future policy is something for a Board to decide upon in conjunction with a Minister ; it could make no reference to wages policy or conditions of service ; not all the evidence given to it need be published. The boot is indeed upon the other foot. Will a committee, under those limitations, have powers enabling it to collect enough information ever fully to inform itself about the work of any Board, let alone direct the attention of the House to any subjects that merit its particular attention ? That, indeed, was the ground upon which the proposal was criticised in debate. Yet the experiment is worth a trial. Starting thus cautiously, room is allowed for further evolution if the proposed committee is found to have value. No great harm is done if it proves ineffective. For ourselves, as engineers, when the advantages and disadvantages of a device or mechanism cannot be fully assessed in advance we like to make a model and see how it works. Thereby more definite information becomes available. Analogously that is precisely what the Government seems to have in mind to do.

IDEOLOGY AND THE ENGINEERING INDUSTRY

The historian of the future will find much matter for reflection when he comes to deal with industrial history in Great Britain during the middle decades of the twentieth century. We live in times when the results of vast political and ideological experiments are having their repercussions on human industry and human behaviour, and when it is possible to make at least a preliminary assessment of the reactions which have been produced. It has been said that human character is shaped by human experience, and it can certainly be said that industry is shaped by industrial experience. Some of the experiments of recent years were bottomed, as must be admitted, in enthusiasm

rather than experience. No one, for example, could affirm that any encouragement was to be drawn from the experience of the nationalised iron and steel industry of Czechoslovakia. In any event, we live not in Bohemia, but in Great Britain, where the iron and steel industry may be said to have originated. It is a complicated industry and, like other technical industries, it is in a continuous process of evolution and cannot be expected to thrive under any leadership lacking in the inspiration and ceaseless activity which has brought it thus far. No Government is able, by Order in Council, to produce individuals of the calibre of Abraham Darby, Wilkinson, Neilson, Bessemer, Siemens, and such men. They are the product of imaginative faculties fed by incessant effort. It is the same with the master men of any industry and to suppose that they can flourish under bureaucratic dictation is to mistake the nature of inventors and technicians.

Again, can it ever be established that workers will function happily and peaceably where their sole employer is the State and they have no redress other than by rebellion ? That is a problem this nation is in process of working out. Someone has remarked that "The State which becomes absolute master of an industry must shortly become absolute master of the individuals working in such industry." The ideologist does not, of course, set out with the idea of putting at hazard the liberty and, indeed, the livelihood of his fellow-citizens, but lacking both practical experience and industrial background he is in ignorance of what lies over the horizon towards which he is guiding the ship. A distinguished Canadian publicist has remarked that : "We who live in rich and privileged North America should see in all this a great lesson. Every time you hear a member of a political party—and it does not matter which party—preaching class hatred under the guise of 'soak the rich,' go wary on him. It is a 'phony' appeal to avarice and envy. It doesn't pay off." The same writer added that the upshot of State management of technical industry would be to weaken effort, bring government into odium, reduce industry to ruin and throw workers into destitution. Let us hope he exaggerated ; that "nationalised" industries, which have come to stay, need not become State-operated, but remain State supervised, as now. Great damage is done by men—irrespective of party—who neglect what is the paramount duty resting on all : that we should do everything in our power to establish that mutual confidence which imparts cohesive force to human society. Mutual confidence is to society what cement is to concrete. The trouble is that vanity inclines men to the foolish consistency which Emerson declares to be "the hobgoblin of little minds, adored by little statesmen and philosophers and divines." We shall do well to remember, moreover, the advice given by Aristotle that it becomes a man to sacrifice even his own opinions and sayings upon the service of the truth. This was put into other and cogent words by the late Lord Balfour, who remarked that "There is no error fatal in politics unless it is persisted in." There is a real danger lest technical and industrial progress—which are the products of technical and industrial enterprise—should be stifled by political interference and bureaucratic inertia. The clear duty of government is to do all in its power to foster enterprise, a thinly cast seed which knows no politics. The precious qualities of enterprise and imagination appear in all sorts and conditions of men and in all categories of human activity. Moreover, it is on the perpetuation of enterprise and imagination that we depend for the maintenance, let alone the improvement, of what is called the "standard of living." An industry deprived of these qualities and lacking in skilled and resolute leadership cannot long survive. Fortunately, there is not, among engineers, that "perpetual reciprocation of malevolence" which is too frequently found in the ranks of party politicians, who are, moreover, prone to take advantage of the fact that "nothing has a greater hold on the human mind than nonsense fortified with technicalities."

Engineers are comparatively rare in Parliament and the only world-renowned representative of the profession whom we can recall as having been a Member of the House of Commons was Robert Stephenson. Nevertheless, much of the time of Parliament has, in the past century, been devoted to problems arising from the activity of engineers and industrialists. Parliament without debate must, of course, be a farce, and government of the kind which we have in Great Britain cannot persist without it. The trouble arises when matters not understood by politicians are kicked about like political footballs instead of being regarded as issues to be debated by those whose experience enables them to comprehend what is involved and who realise, with the late C. P. Scott, that "while comments are free, facts are sacred."

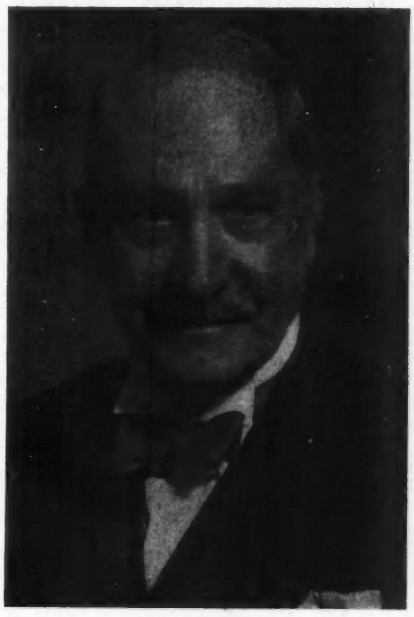
Obituary

W. A. TOOKEY

THE death of Mr. W. A. Tookey, which occurred at his home at Bromley, Kent, on Tuesday last, February 9th, will be deeply regretted by the many engineers who knew him, and particularly by the older members of the profession. For more than forty years Mr. Tookey practised in Westminster as a consultant, and also took an active part in the work of the engineering institutions.

William Alfred Tookey was born at Greenwich on June 9, 1871, and received his general education there at the Roan School. Subsequently, he studied at the Birkbeck Institute, in London, and began his practical training as an engineer with two Greenwich firms, A. H. Bateman and Co., Ltd., and Appleby Brothers, Ltd. In 1889, Mr. Tookey joined the staff of Tangyes, Ltd., remaining with that firm for the next fifteen years. For a start he was engaged in the drawing-office, and later on had charge of the department which was responsible for the installation of steam, gas and oil engines and the pumps made by the firm.

Mr. Tookey started to practise as a consultant in Westminster in 1905, specialising in matters concerned with all kinds of power-house machinery and power transmission appliances, and particularly with the application and operation of internal combustion engines. In connection with the latter, it may be recalled, he evolved a method of comparing the output of power from internal combustion engines with the relative richness of charge, which method has been known since 1914 as the "Tookey Factor." Amongst the work which Mr. Tookey undertook in his earlier years in Westminster was the surveying and testing of more than 1000 engines fed by public gas mains in the London area, a task which was carried out for the Gas Light and Coke Company and the South Metropolitan Gas Company. Mr. Tookey retained his practice in Westminster until towards the end of the second world war, when bomb damage to his office compelled him to conduct his professional affairs from



W. A. Tookey

his home. It cannot be said that he retired, for, although in recent years he had reduced his activity, his interest in technical matters remained as keen as ever.

The part that Mr. Tookey took, throughout his long career, in the work of various professional institutions was no small one. He was elected a member of the Institution of Mechanical Engineers in 1912, served for some years on its Oil Engine Trials Committee, and contributed several papers to its Proceedings. He was also a member of the Institute of Fuel, the Diesel Engine Users Association, and the Association of Consulting Engineers, and, for a time, served as chairman of the internal combustion engine panel of the British Standards Institution. The two institutions to which Mr. Tookey gave outstanding service, however, were the Institution of Automobile Engineers and the Junior Institution of Engineers. He acted as honorary treasurer of the "Automobiles" (prior to its amalgamation with the Institution of Mechanical Engineers), and was elected to its presidential chair in 1931. His presidential address to the "Automobiles," which he delivered in October, 1931, very effectively surveyed the various stages of development of the internal combustion engine since the 1890s. Mr. Tookey's valuable and continuous work for the Junior Institution of Engineers is well known. He became a member in 1904, served successively as chairman, treasurer, and for a period after the first world war as honorary secretary, and was elected president in 1937. All who have attended the annual dinners of the "Juniors" will remember with particular pleasure Mr. Tookey's felicit-

ous discharge of the office of toast-master, calling, with the spanner as a gavel, members and guests alike to take wine—and sometimes snuff—with the President ! The geniality which W. A. Tookey showed not only on these, but on all occasions, combined with his technical ability and his readiness to help at all times, were characteristics which will not be quickly forgotten by all who knew him.

Literature

Electro-Magnetic Machines. By R. LANGLOIS-BERTHELOT. London : MacDonald and Co. (Publishers), Ltd., 16, Maddox Street, London, W.1. Price 65s.

IT has been well said that there is a need for a " new look " in the analytical treatment of electrical machines and in the methods used in teaching this subject. The translation into English of the books of Langlois-Berthelot, which have already been very well received by French engineers and teachers, is very welcome because they introduce a new and better point of view. In recent years several new general textbooks on electrical machines have appeared in England and America, but this one is the first to avoid the rather piecemeal approach which has been characteristic of such books since the early days. Langlois-Berthelot's books are also more up to date in many practical respects than most of the general textbooks.

The French edition of the complete work was published in 1949 in four separate volumes covering the following subjects :—

(1) Electrical machines from the general electro-magnetic point of view.

(2) Electrical machines from the general industrial point of view.

(3) The machines used for generation and distribution (synchronous machines and transformers).

(4) The machines used in industrial applications (induction motors, d.c. machines, &c.).

The book under review contains the subject matter of the first two French volumes. A second volume corresponding to the third and fourth volumes is mentioned in the Preface, and will presumably be published later.

The book is ably translated by the author in collaboration with Mr. Clarke. It is easy to read and retains very well the semi-conversational style of the original French work. It is not by any means a literal translation, but is rearranged and considerably shortened ; in both respects with advantage for an English reader. There are a few places where the wording retains a foreign flavour ; for example, the word " type " (page 64) is used where we should say " frame size." The description of a transformer as an " apparatus with a cylindrical core," to distinguish it from a rotating machine, seems rather strange.

The book is intended, first, for the practising engineer who is concerned with electrical machines and, secondly, for the student. It does not contain the specialised material required by designers, although they would find its enlightened point of view interesting. For supply, industrial and production engineers it provides an easy and attractive means of broadening their knowledge. It is particularly opportune in view of the ever-increasing collaboration between the industrial and supply undertakings of England and France.

For the student the position is rather more doubtful. In the first place, the book is too lengthy, even in the shortened form of the English translation. An ordinary student cannot cope with two volumes each containing 500 pages. Further, the logical sequence is not quite that required by a student meeting the subject for the first time. Nevertheless, the book contains all the ideas and all the material he needs. It is in fact more suitable for the teacher than for the student. It is strongly to be recommended that all teachers of electrical engineering should study this book.

There are six parts, of which the second is probably the most important. Part II is entitled " General Anatomy and Physiology of Electrical Machines." In this section the usual simplified methods of analysing electrical machines are related to the fundamental electro-magnetic laws in a very clear manner, and in most cases without using advanced mathematics. It is well recognised that the average French engineer has a better mathematical foundation than his English counterpart, and this fact is to some extent reflected in the book. There is, however, nothing to deter any engineer from studying most of its contents. The large number of little drawings and diagrams of windings, core arrangements, voltage relationships, and so on, are extremely helpful. Parts III to VI deal with many practical matters from a general point of view without entering into excessive detail. The topics discussed include insulation, cooling, losses, commutation, specification and testing, and various abnormal conditions of operation.

However, the important feature of the book is the new point of view presented in it. In the early days of electrical engineering, when rotating machines formed the principal part of a student's course, it was permissible to treat the alternator as one subject and the induction motor as another, and to spend many hours on the detailed design of these machines. Nowadays the much wider range of subject matter to be studied can only be dealt with by concentrating on the essential general points, by excluding all non-essential details, and by developing a general theory which embraces many different practical forms of the apparatus. This process is being applied in other branches of scientific work, and it should also be used for electrical machines. The book by Langlois-Berthelot makes a very good start.

SHORT NOTICES

Introduction to Ultra-High-Frequency Radio Engineering. By Stephen A. Knight, F.R.S.A. London : Sir Isaac Pitman and Sons, Ltd., Parker Street, Kingsway, W.C.2. Price 21s.—The primary purpose of this book is, in the author's own words, " to provide an introduction to the possibilities of ultra-high-frequencies for those whose interests lies in their applications and the lure of experiment in new domains of the electromagnetic spectrum." It makes no attempt to give a logical exposition of a particular application, such as television or radar ; the aim is rather to provide some ground work in u.h.f. techniques, without introducing unnecessary detail. The reader is assumed to have a reasonable knowledge of radio frequency work and of the corresponding elementary mathematics. To cover the subject in a book of 256 pages the author has had to make a selective approach. Some indication of the scope of the text may be obtained from the chapter headings—An Introduction to Microwaves ; Transmission Lines ; Waveguides ; Cavity Resonators ; Cathode-ray Tubes and Sweep Circuits ; U.h.f. Oscillators (negative and positive triodes and magnetron and klystron oscillators) ; Wave Propagation and U.h.f. Aerial Systems.

Practical Metrology : Volume I, Experiments. By K. J. Hume, B.Sc., M.I.Mech.E., and G. H. Sharp. London : Macdonald and Co. (Publishers), Ltd., 16, Maddox Street, W.1. Price 6s.—This book is designed to assist students of engineering metrology in their practical laboratory work and the experiments it describes can be carried out with relatively simple equipment which is generally available. It opens with notes on the apparatus required for the experiments and its care, and general particulars are given of procedure. The twelve experiments dealt with in detail include measurement of a double-ended plug gauge ; of a gap gauge ; the height of a circular spigot, a flush-pin depth gauge, a plain ring gauge, a taper plug gauge, a taper ring gauge and a plug screw gauge ; the calibration of a micrometer and the checking of a straight edge and an engineer's square. The clear, concise presentation of the information will appeal to students, who will find this book a useful reference work for their studies in the laboratory.

The Synchronous Induction Motor. By J. Griffin, A.M.I.E.E. London : Macdonald and Co. (Publishers), Ltd., 16, Maddox Street, W.1. Price 18s.—The synchronous induction motor, as the author points out, originated on the Continent at a time when power systems were small and starting currents had to be correspondingly small. It has survived, largely as a British development, because it combines the starting characteristics of the wound-rotor motor with the improved power factor of the synchronous motor. Most of the existing published information on the synchronous induction motor is scattered in a number of journals and periodicals, and the book under review should appeal to those who want a single short but comprehensive review of the whole subject. The author has aimed at presenting the graduate engineer and junior designer with an overall picture of modern practice with particular reference to developments that have taken place since L. H. A. Carr's review of the subject in the *Journal of the Institution of Electrical Engineers* in 1920. Not the least interesting part of this book is an appendix acknowledging Ernst Danielson—who was then chief engineer of Allmanna Svenska Elektriska Aktiebolaget (A.S.E.A.)—as the inventor of the synchronous induction motor and giving a translation of Danielson's article, " The Induction Motor as a Synchronous Motor," which appeared in German in the *Elektrotechnische Zeitschrift* of December 26, 1901 (Vol. 22).

BOOKS RECEIVED

Railroad Engineering, Vol. I. By William W. Hay. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 60s.

Mechanics of Materials. By E. P. Popov. London : MacDonald and Co. (Publishers), Ltd., 16, Maddox Street, W.1. Price 70s.

A Message Round the World. By Marie Neurath. London : Max Parrish and Co., Ltd., 55, Queen Anne Street, W.1. Price 6s.

Industrial Inorganic Analysis. By Roland S. Young. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 36s.

Fabricated Materials and Parts. By Theodore C. Dumond. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 52s.

The Motor Vehicle. By K. Newton and W. Steeds. Fifth edition. Iliffe and Sons, Ltd., Dorset House, Stamford Street, S.E.1. Price 35s.

Plastics Progress, 1953. Edited by Phillip Morgan. London : Iliffe and Sons, Ltd., Dorset House, Stamford Street, S.E.1. Price 50s.

An Introduction to Railway Engineering. By Ronald A. Inglis. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 21s.

Battery Chargers and Charging. By Robert A. Harvey. London : Iliffe and Sons, Ltd., Dorset House, Stamford Street, S.E.1. Price 35s.

Locomotive and Train Working in the Latter Part of the Nineteenth Century, Vol. 5. By E. L. Ahrons. Cambridge : W. Heffer and Sons, Ltd., Cambridge. Price 15s.

Theoretical Naval Architecture. By Edward L. Atwood and Herbert S. Pengelly. London : Longmans, Green and Co., 6 and 7, Clifford Street, W.1. Price 40s.

Calculation, Design and Testing of Reinforced Concrete. By K. L. Rao. Second edition. London : Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 35s.

American Gas Turbines in 1953

(By Our American Correspondent)

DURING the past year, a considerable number of new orders were received by both The General Electric Company and the Westinghouse Electric Corporation for their " standardised " industrial gas turbine plants, and, as a result, both firms have increased their manufacturing facilities for such equipment, situated, respectively, at Schenectady, New York, and South Philadelphia, Pennsylvania. The majority of these " mass produced " gas turbines are of simple or regenerative open cycle, single or two shaft design, ranging in rated capacity from 3500kW to 5000kW and offering thermal efficiencies of only between 15 and 24 per cent. The three major applications of these units are as prime movers for centrifugal-compressor natural-gas pumping plants, for railway locomotives and for base load or standby generating service in electric power stations. To obtain reliable operation in the field, the gas turbines are conservatively designed and generally have a maximum turbine inlet temperature of 1450 deg. Fah.

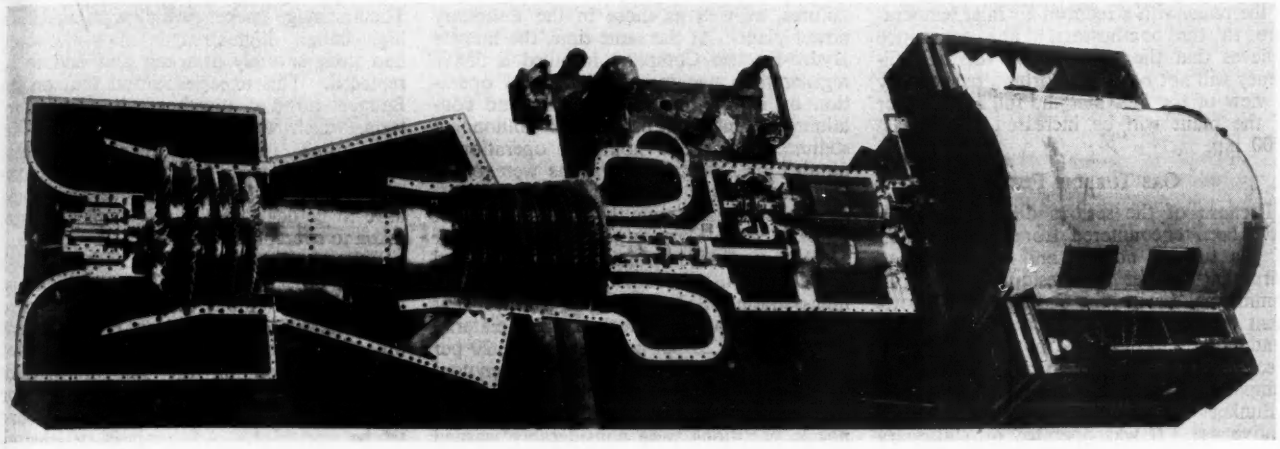
Representative of these commercial power plants is the 5MW Westinghouse simple open cycle, single shaft gas turbine generator which was recently installed at the Fort Stockton power station in Texas of the West Texas Utilities Company, and which is shown during erection in the accompanying illustration. This set has a sixteen stage compressor and a compression ratio of approximately six. At the full load speed of 5700 r.p.m. the compressor flow is 111 lb per second. The temperature at the inlet of the five stage gas turbine is 1350 deg. Fah. The full load efficiency of this unit is 18·9 per cent at the generator terminals based on the h.c.v. of residual (" Bunker C ") fuel oil. The compressor combustor and turbine are contained in a single assembly, resulting in a compact unit of great simplicity. All cylinders have horizontal joints to facilitate assembly, inspection and maintenance. The six can combustors are disposed radially around the compressor discharge between the compressor and the turbine, resulting in a unit with minimum length and maximum combustor accessibility. There are only two bearings for the compressor and the turbine, and both bearings are accessible for inspection without removing the cylinders. This bearing arrangement eliminates the problems of air and oil sealing required if the bearings are situated between the compressor and the turbine, and it also minimises the effects of possible external misalignment.

The gas turbine power plant drives a conventional 5MW, 0·8 power factor, air-cooled generator and exciter through a single reduction gear. Many of the auxiliaries for this unit have been grouped on the oil reservoir to form an assembly, including the oil coolers, the auxiliary and emergency lubricating oil pumps, the governor and fuel control valve, and various safety devices.

The gas turbine can be arranged to burn either gas or liquid fuel by a change of the fuel nozzles and valves.

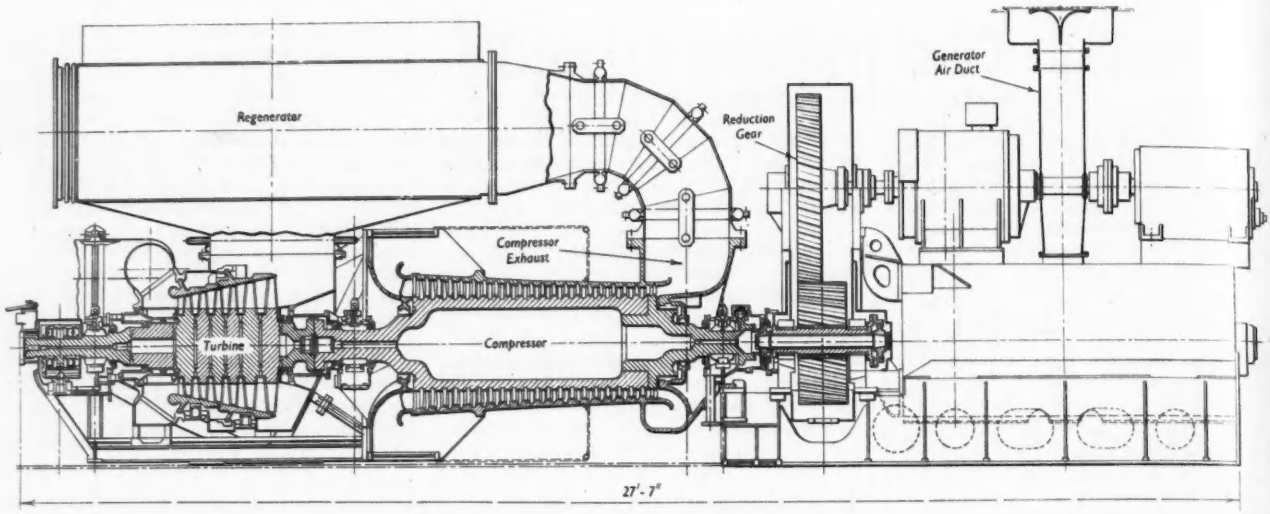
The 15MW Westinghouse gas turbine generator set, now under construction for the Public Service Company of Oklahoma, will be the largest gas turbine power plant in the United States. By comparison with the smaller plants, this machine is a high efficiency unit operating on the open cycle and using both regeneration and inter-cooling. The plant consists of low and high pressure axial-flow compressors driven by low and high pressure turbines, respectively. Both the high and low pressure turbines are designed for operation at 3600 r.p.m. and the generator is driven by the high pressure compressor shaft, requiring no reduction gears. Air is drawn into the low pressure compressor and passes through the inter-cooler to the high pressure compressor. It then enters the regenerator and passes to the combustor. The gases at 1350 deg. Fah. are then expanded through the high pressure turbine which drives the generator and the high pressure compressor. Further expansion of the gases through the low pressure gas turbine provides the power to drive the low pressure compressor. The exhaust gases then pass through the regenerator. The full load efficiency of this power plant is 26·5 per cent at the generator terminals based on the h.c.v. of residual oil. The efficiency level of this cycle compares favourably with a 15MW steam power plant using inlet steam conditions of 850 lb per square inch gauge and 900 deg. Fah. with four stages of feed water heating.

The Locomotive Development Committee of Bituminous Coal Research, Incorporated, has completed the first phase of its test programme on a coal-burning gas turbine locomotive power plant of 3750 h.p. rated capacity, which was built by the Allis-Chalmers Manufacturing Company and erected within locomotive cab contour limitations at Dunkirk, New York. A sectional view of this installation is illustrated on the next page. Initially, the plant was operated for a preliminary period of 178 hours, during which the maximum load carried for any significant period of time was 2000 h.p. The machine was then dismantled for inspection and minor alterations. No erosion of any importance was found on the turbine blading. The machine was then put back into service and a 750 hour test was run, with a total coal consumption of more than 2,000,000 lb, at an average rate of 2840 lb per hour, and an average turbine load of 2760 h.p. The average specific fuel rate was 1·03 lb of coal per h.p., giving an average thermal efficiency of 18·7 per cent. The average turbine inlet temperature was approximately 1200 deg. Fah. The best thermal performance was reached at 3000 h.p., where the specific fuel consumption was approximately 0·95 lb per h.p., giving a thermal efficiency slightly above 20 per cent. The plant reached its rated capacity, 3750 h.p., without difficulty, and its maximum capacity thus far has been 4250 h.p.



Open Cycle 5MW Gas Turbine Generator during Erection at Fort Stockton Power Station, Texas

The longest single run has been twenty-four hours, while the average test run has been four hours. The combustion efficiency was consistently above 95 per cent and the two combustors were in good condition at the end of the test. An interesting achievement was the demonstration of a coal-burning power plant for locomotive service which complies with even the most stringent smoke control ordinance. The dust emission was approximately 0·2 lb per 1000 lb of exhaust, while most American ordinances in effect to-day permit as much as 0·85 lb of dust per 1000 lb of stack gas. The appearance of the stack even at full load was good, with only a greyish haze being visible. The main difficulty encountered during the initial test programme was a gradual erosion of the turbine blades. This was due to difficulties encountered in the fly ash separator, which, from time to time, resulted in the passage of coarse ash through the turbine. A new and improved fly ash separator has now been constructed and installed. The committee's plans for the next series of tests, which will commence early in 1954, include the elimination of the regenerator to determine the performance



Coal Burning 3750 h.p. Gas Turbine for Locomotive Service

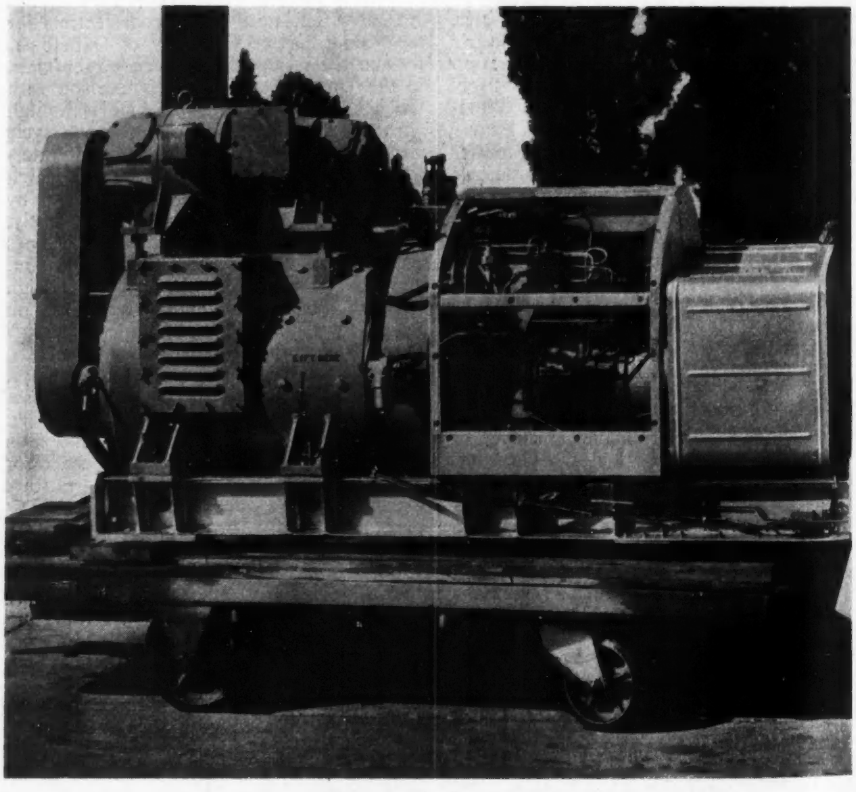
of the plant with a reduced air inlet temperature to the combustors. The committee believes that the reduction in thermal efficiency will not be too important, particularly in view of the fact that the full load power of the plant will be increased to at least 4500 h.p.

Gas Turbine Fuels

Because of the serious difficulties which have been encountered from the corrosion of gas turbine nozzles and buckets when burning "Bunker C" residual fuel oil in commercial service, the Gas Turbine Department of The General Electric Company is conducting a programme of tests aiming at a solution of this problem. The first of the company's gas turbines to operate on "Bunker C" fuel was designed for locomotive use. It was operated on stationary test at the factory in Schenectady and on the test track in Erie, Pennsylvania, for approximately 800 hours, during which more than 250,000 U.S. gallons of "Bunker C" were burned. During factory test and after 492 hours of fired time, the first stage turbine nozzle was oxidised to such an extent as to require replacement. The nozzle was inspected a number of times during the course of the test and no oxidation was apparent for the first 390 hours. Following the shop tests, this locomotive power plant was operated in a locomotive on various railways but principally on the Union Pacific, for a total operating time of 5700 hours. During this time approximately 1,500,000 gallons of "Bunker C" were burned and four first-stage turbine nozzles were ruined by corrosion, apparently from the fuel oil ash. The four nozzles involved ran from a minimum of 1000 hours to a maximum of 1600 hours each before requiring replacement.

Shortly after the above locomotive began its railway service, a 3·5MW gas turbine generator set similar in design to that of the locomotive unit was installed in the Farmingdale power station of the Central Maine Power Company at Gardner, Maine. Very rapid corrosion occurred in the first stage nozzle of this plant which was using a high-vanadium fuel containing 246 parts per million of vanadium. Initially it was thought that sodium sulphate, which was known to be a constituent of the ash deposit, was not corrosive. This supposition, together with the vanadium corrosion which had occurred on the nozzles, led the company to believe that vanadium was the principal corroding agent in the locomotive nozzle failures, as well as those in the stationary power plant. At the same time, the Bangor Hydro-Electric Company installed a 5MW regenerative machine which started operation on an oil low in vanadium and containing twenty-six parts per million of sodium. After 340 hours of operation a number of first-stage partitions were badly corroded and the entire nozzle was replaced. At about the same time the Central Vermont Public Service Company installed a similar 5MW regenerative turbine which also started operation on a relatively low-vanadium, high-sodium oil but using a 28 per cent chromium stainless steel nozzle material instead of the 25 per cent chromium, 20 per cent nickel stainless steel which had been used in the others. After approximately 500 hours of operation on "Bunker C," some of the nozzle partitions were considerably warped but none of them were seriously corroded. The first stage buckets, which were made of a high-cobalt, high-strength alloy, however, had been severely attacked and had to be replaced. This experience and that on the Bangor turbine, together with laboratory tests, which were completed at about the same time, indicated rather clearly that sodium sulphate as well as vanadium pentoxide could be highly corrosive and would have to be dealt with in any steps that were taken to overcome corrosion.

Following these troubles with the high sodium oils, both the Bangor turbine and the Central Vermont turbine were operated for some time on American No. 2 heating oil. Unexpectedly, this oil also caused some oxidation on the Bangor machine to the extent that after 470 hours of operation the first stage nozzle partitions were found to be corroded. An analysis of the oil which was being burned at the end of this



500 h.p. Gas Turbine Generator Set

period showed only a few parts per million of either sodium or vanadium and no other constituents that could be expected to be harmful. From this experience and studies made on the combustion chambers, it was concluded that the corrosion occurring in this nozzle was probably due to flame impingement, resulting in alternating oxidising and reducing conditions, which are known to be harmful to most stainless steels. Such impingement was undoubtedly present in all of the operations on " Bunker

45 h.p. Aircraft Gas Turbine Generator Set

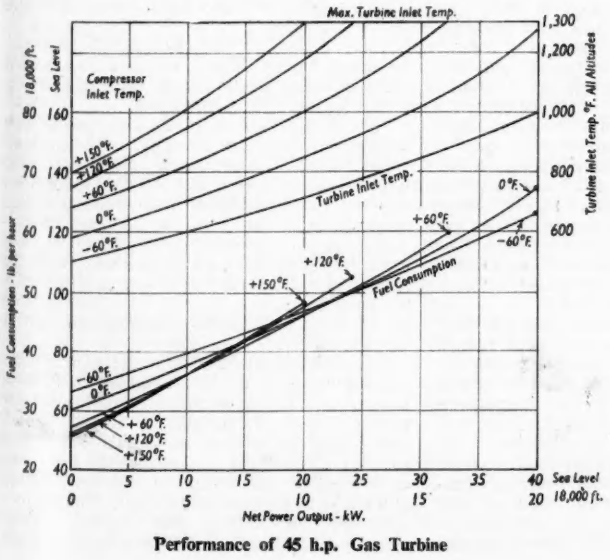
C " fuel of the 5MW units tested, which made it all the more difficult to deduce with certainty just what was responsible for the corrosion in each case. Shortly after the failure by corrosion of the first locomotive nozzle during factory test, a programme of laboratory investigations was started employing crucible tests and small burner tests to learn more about the nature of oil ash corrosion and things which might be done to prevent it. This programme has continued from that time on and is still being actively pursued. Specifications to govern the quality of residual fuel oils for gas turbine service have been developed and certain tests modifying the oil at the point of use are being made on one of the stationary machines. The effects of adding oil-soluble compounds, slurries of suspended particles and emulsions of water solutions with the oil are being tried. It is expected, however, that this method of obtaining a non-corrosive residual oil will be an interim phase of the development only. Work is being done in co-operation with several oil companies to explore other ways of producing non-corrosive residual oils and to explore ways of supplying commercial quantities of such oils to users of gas turbines.

Free Piston Gas Generators.—In THE ENGINEER, January 22nd, an account was given of the development in America of free piston gas generators for feeding gas turbines. The units described are those built by the Cooper-Bessemer Corporation of Mount Vernon, Ohio, and the Baldwin-Lima-Hamilton Corporation of Hamilton, Ohio.

AUXILIARY GAS TURBINE PLANTS

A number of its " Jupiter " 500 h.p. gas turbines were delivered to the U.S. Navy in the course of the past year by the Solar Aircraft Company, of San Diego, California. The constant speed version of this unit is being employed to power a shipboard electric generating set, and one of these turbo-generators is shown in an illustration on page 250. It is only 6ft long and less than 3ft in both height and width and is said to be equivalent to diesel engine-driven units more than four times its size and weight. A similar gas turbine, having a variable speed output, will be used by the U.S. Navy for the propulsion of small craft. A detailed description of the " Jupiter " engine appeared in THE ENGINEER of March 28, 1952, page 428.

The " Mars " 45 h.p. gas turbine was originally developed by the Solar Aircraft Company as the prime mover for a light-weight portable fire-fighting pump with an output of 500 U.S. gallons per minute at 100 lb per square inch. Its low weight-to-power ratio and reliable performance soon suggested its application in airborne generator sets. Two models have now been tested and are in current production. The " T-41M-1 " provides 8kVA of a.c. and up to 14kW of d.c. power. The " T-41M-2 " is a d.c. generating unit rated at 14kW. One of the latter is shown in the accompanying illustration prior to being installed in one of the " C-124 " " Globemaster " cargo and troop transport aircraft built by the Douglas Aircraft Company. Both of these airborne generator sets have passed the full qualification tests of the U.S. Air Force, including a 200 hour endurance test and environmental tests, involving start and operation at temperatures ranging from +130 deg. Fah. to −65 deg. Fah., and start and operation at altitudes up to 20,000ft. The acceleration and running of the generator sets is fully automatic from the moment a starting signal is fed to the control system by closing a switch either manually or automatically. Although the specification requirement for speed regulation is ±5 per cent, the governor system actually holds speed within ±3 per cent. Automatic over-temperature and over-speed protection is provided.



Performance of 45 h.p. Gas Turbine

The power source of the generator sets is a simple and compact gas turbine engine, which operates at a speed of 36,400 r.p.m. on high octane petrol, jet propulsion fuels or diesel oil. It incorporates a reduction gear to reduce speed to the two available outputs of 4500 r.p.m. and 6000 r.p.m. The impeller of the centrifugal compressor and the radial, inward-flow turbine rotor are mounted back-to-back on the same shaft, separated by a seal plate. Inlet air enters the compressor through a screened annular opening. The compressor scroll encircling the impeller collects and directs the compressed air into the combustor, where fuel is injected. Combustion gases then flow to the turbine scroll and nozzle and impinge radially inward against the rotor vanes. The gases then flow inward and turn to exhaust axially through a short tail-pipe. A portion of the compressor discharge air is bled off to circulate through a cooling shroud surrounding the turbine. Ignition at starting is furnished by a spark plug and a booster coil. The turbine is accelerated to approximately 5000 r.p.m. by the d.c. generator acting as a motor. At this point momentary ignition takes place and the turbine accelerates under a combination of its own power and help from the starter to a speed of about 16,000 r.p.m. The motoring action of the generator is then automatically discontinued and the engine accelerates to operating speed. The full starting cycle is completed in less than ten seconds. Fuel flows from the supply through a filter, fuel pump and governor to the spray nozzle in the combustor. Lubricating oil is pumped to the bearings under pressure and scavenged back by gravity to the oil reservoir and sump, which is situated in the reduction gear housing. The speed change between turbine and output shafts is accomplished in a single, spiral bevel gear reduction. The graph, which is reproduced herewith, shows turbine performance at sea level and at 18,000ft. It assumes a generator efficiency of 80 per cent and makes allowance for power losses involved in cooling the generator.

Works Apprentice School

FOR many years the training of apprentices has been regarded as a matter of particular importance by Baker Perkins, Ltd., of Peterborough. During the war the firm decided that it would have to depend on training its own future craftsmen and that existing arrangements for training apprentices would have to be overhauled so as to provide a comprehensive scheme which in the years to come would ensure an adequate supply of young craftsmen and technicians.

In 1945, after a survey of the best methods of training engineering apprentices in this country and abroad, a scheme was approved which provides for direct entry from each of the educational levels in this country—from the Secondary Modern and Technical Schools, from the Secondary Grammar School, from the Public School and from the University.

An important stage in this works training scheme was recently reached with the opening of a new building embodying a complete training establishment. This new school is provided with all the equipment needed for training apprentices in the proper use of the tools of their crafts. There is a well equipped machine shop, fitting shop and plate working section, and a combined lecture hall and gymnasium.

Manchester–Kirk o'Shotts Television Radio-Relay System*

By G. DAWSON, B.Sc.,† L. L. HALL,† K. G. HODGSON, B.A.,† R. A. MEERS† and J. H. H. MERRIMAN, M.Sc.‡

The first permanent broad-band super-frequency system to be operated in Great Britain was put into public service in March, 1952, to relay television programmes between Manchester and Kirk o'Shotts and so extend the B.B.C. television service to Scotland. The paper discusses the considerations which led to the adoption of a 4000 Mc/s radio-relay system for this service, and gives a detailed description of the design and performance of the equipment. The conclusions which have been drawn from some fifteen months of daily operation are given.

In 1948 the Television Advisory Committee recommended that more high-power television broadcasting stations should be constructed, which, with the then existing stations at Alexandra Palace and Sutton Coldfield, would extend the television service area to cover 80 per cent of the population in the United Kingdom. The B.B.C. decided to build stations at Holme Moss, Kirk o'Shotts and Wenvoe, and the Post Office had to consider the means of providing a permanent television transmission system to serve these stations. The Post Office and the B.B.C. agreed that this system would consist of independent channels in each direction of transmission between defined switching points with injection and distribution facilities at these points. This would enable programmes to be distributed from the main studio centres in London, and outside-broadcast material to be injected at other places, whilst retaining a high degree of flexibility of operational control.

The Post Office were at that time transmitting television signals between London and Sutton Coldfield by both a v.h.f. radio link using frequency-modulation[1] and a vestigial-sideband system over a 1in diameter coaxial cable.[2] A multi-tube coaxial cable was being installed between Birmingham and Manchester, and it was decided to use a vestigial-sideband system on two of the ¾in tubes in this cable for television transmission.[3] A plan for a national network was gradually evolved.[4]

As the plans for the extension of the telephony coaxial-cable system northward from Manchester were not very advanced in 1948, consideration was given to the use of radio for the circuits between Manchester and Kirk o'Shotts. It appeared that the use of radio for television alone would require a smaller initial capital outlay than the use of a coaxial cable with its associated telephony requirements, and also that a radio link would be provided more quickly than a coaxial-cable system.

It was therefore decided that a radio link was preferable, and a choice had to be made between a route via Carlisle to the west of the Pennines, or a route via Leeds, Newcastle and Edinburgh to the east of the Pennines. As the easterly route passed through many centres which could provide important outside broadcasts, and could also serve the low-power television transmitter—which has since been built at Newcastle (Pontop Pike)—it was chosen. Seven intermediate stations are used; the average link length is 31 miles, the shortest (Manchester to Windy Hill) being 13 miles and the longest (Corby's Crags to Blackcastle Hill) 47 miles, with a total route length of 247 miles.

The use of centimetric waves for communication has been the subject of experiments and developments by radio engineers for many years, and as long ago as 1931 a cross-channel radio link operating between St. Margaret's Bay and Calais on a frequency of 1700 Mc/s was demonstrated. In the following year a similar permanent system[5] was installed between Lympne and St. Inglevert, which carried telegraph traffic until the start of the 1939–45 War.

Between 1938 and 1946 much research effort was employed in developing methods of using frequencies of about 3000 Mc/s for radar. During this period a broad-band amplifier for super-frequency waves (the travelling-wave amplifier) was invented by Kompfner.[6]

At the end of the 1939–45 War, work was started to apply these techniques to broad-band communication systems. It was found that operation as part of a permanent point-to-point communication network would prescribe for system components considerably higher standards of linearity and long-term reliability than those used for radar. During the period immediately following the war, research and development was particularly devoted to the production of waveguide components of better performance, and valves of greater reliability, than were used in wartime radar equipments.

In accordance with the recommendations of the Atlantic City Convention[7] fixed point-to-point communication links may be operated in the United Kingdom in the following bands:

1750–2300 Mc/s
3900–4200 Mc/s
5925–8500 Mc/s

and a choice had to be made between these alternatives. V.h.f. operation was not considered, since the wide system band-widths required for broad-band communication cannot readily be accommodated therein.

The advantages of using the highest possible carrier frequency are increased gain of aerials for a given size, leading to the use of smaller transmitter powers and giving increased protection against interference and echo signals, and reduction of the signal-band-width/carrier-frequency ratio. Against these advantages must be offset the increased liability to atmospheric attenuation and fading, as well as the increased difficulty of achieving low receiver noise factors and signal-frequency gain as the frequency is increased.

Taking into account not only these factors, but also the accumulated experience of radar techniques in the nearby 3000 Mc/s band, and the recently developed travelling-wave amplifier, it was decided to develop equipment for use in the 3900–4200 Mc/s band.

At the time the contract was placed, in 1950, experimental equipment was already in existence and development was sufficiently advanced to demonstrate that a system working in the 3900–4200 Mc/s band could meet the specification.

Specification of System

The main operational requirement for this television relay system was the achievement of a very high standard of overall reliability, together with the need to arrange that all intermediate repeater stations could be operated continuously on an unattended basis with routine maintenance visits once a month. The specification called for duplicate equipment at each station and for each direction of transmission, and also that equipment common to both main and standby paths should be of a static or robust nature, and that all equipment requiring routine maintenance should be at ground level. In addition, it was hoped that the system could be planned so that it could be expanded at a later date to enable additional television channels or multi-supergroups of telephony channels to be provided. It was also necessary to make arrangements for an injection point at each intermediate repeater station so that locally originating outside-broadcast programmes could be fed into the main network. The terminal control stations at Telephone House, Manchester, and at Kirk o'Shotts, were to be the only continuously attended points on the system and the complete monitoring and supervisory facilities necessary to control the systems were to be concentrated at these points.

Tentative transmission standards on the basis of a 500-mile system only, with four typical links in tandem, had been agreed between the Post Office and the B.B.C.[4], although it was not practicable to specify rigidly the apportionment of these overall standards to individual links. In order to provide a certain factor of safety on the 500-mile system performance, and to minimise the overall performance variations as different combinations of the four links are used, the following overall transmission performance requirements for this particular system were defined [as summarised in the paper]:—

Attenuation/Frequency Characteristics

Frequency	Attenuation limits, db relative to zero at 10 kc/s
kc/s 10–2000	A uniform increase on a linear frequency scale from ±0·2 to ±1·0
2000–3000	±1·0

Propagation

During the past decade much experimental work has been done on the propagation of super-frequency waves over land and water paths.[8,9,10] It had been general experience that over the type of terrain along the route between Manchester and Kirk o'Shotts propagation conditions would be reasonably stable if the length of path between repeater stations did not exceed about 40 miles, and if there was a line-of-sight path between each transmitter and receiver with "first Fresnel zone clearance" of intervening obstacles.

A study of the ground contours along the route showed that either seven or eight repeater stations would be required between Manchester and Kirk o'Shotts, if these conditions were to be satisfied, and that the maximum tower height would be about 200ft at Blackcastle Hill, near Dunbar. The choice between seven or eight repeater stations depended upon the liability to excessive fading of the 46·6-mile path between Corby's Crags and Blackcastle Hill, which could be divided into a 32·5-mile and a 14·5-mile path by the introduction of an eighth repeater station near Wooller. The reduced liability to fading by the provision of an extra station had to be balanced against the extra initial and maintenance costs of the station.

In the absence of detailed information on the long-term propagation characteristics of the 47-mile path and in view of the difficulty of erecting a 200ft temporary mast for propagation tests over this section, it was decided that initial planning should be based on the use of seven repeater stations, and that if operational experience demonstrated that excessive fading was being experienced, the additional intermediate station would be introduced at a later date. Experience to date has amply justified the risk taken, and plans for the erection of that additional station have been cancelled.

Propagation tests between each station site were started in September, 1950, for a period of at least sixty hours over each path, and continuous records were made of the received level for a constant transmitter output power. As a result of these tests the tower heights, which had been estimated from the land contours, were adjusted to their final values.

A long-term propagation test between Tinshill and Arncliffe Wood was started in April, 1951, and this was later extended to cover simultaneously the Arncliffe Wood—Pontop Pike path, as it was considered that there may be simultaneous fading on both paths since they both traverse the flat Plain of York.

[The results of these tests are discussed in detail in the paper.]

The short-period tests established that, with the tower heights chosen free-space transmission could be expected for a large percentage of the time on all sections of the route.

Two identical sets of terminal equipment were constructed for the propagation tests, each consisting of a combined transmitter and receiver operating at about 4000 Mc/s, so that a duplex circuit could be set up for communication purposes over each path. A common coaxial-line oscillator was used as the transmitter and local oscillator in each equipment, and the receiver consisted of a silicon-crystal mixer, a pre-amplifier and a main i.f. amplifier centred on 60 Mc/s, a frequency discriminator and a video amplifier.

Lightweight portable steel masts, of triangular section, which could be erected up to 100ft in height, were used to mount the 4ft-diameter paraboloids at the calculated height at each site. Standard-section waveguide runs were used to connect the paraboloids to the transmitter/receiver equipment, which was housed in a trailer at the base of the mast. The paraboloids were adjustable in elevation and bearing, and it was checked that maximum signal strength

* Abstract. Institution of Electrical Engineers, Radio Section paper. London, February 4, 1954.
† Standard Telephones and Cables, Ltd.
‡ Post Office Engineering Department.

was obtained along the theoretical line of shoot.

The path loss was estimated by measuring the output power of the transmitter with a thermistor bridge and calibrating the receiver with an s.f. signal generator. The gains of the aerials were measured before the tests, and the waveguide attenuation before and after the tests. It is estimated that the experimental error of the recorded results is about ±2db.

By frequency-modulating the transmitter with a known frequency deviation it was checked that no undue interference was being received at any site.

General Description of System

Two carrier frequencies, of 3918·75 Mc/s and 3956·25 Mc/s at band centre, are employed for the signal transmission, and they are frequency-modulated 6 Mc/s d.a.p. (i.e. 4·2 Mc/s from black to peak-white level) by a peak-white television signal.

At the transmitting terminal an s.f. oscillator is directly modulated by the incoming video signals, and the frequency-modulated output is amplified by a travelling-wave amplifier. Amplification of the frequency-modulated carrier power is achieved at the repeater stations without demodulation, by changing the frequency to 60 Mc/s (band-centre) and amplifying the i.f. signal before reconversion to super frequency and retransmission. The travelling-wave amplifier[11] is used for amplification of the s.f. signal at the output of each repeater.

At the receiving terminal a frequency-changer converts the incoming radio frequency to an intermediate frequency of 60 Mc/s before demodulation by a discriminator.

Four 10ft diameter paraboloids are used at each repeater station (a transmitter and receiver for each direction of transmission), which are mounted on towers varying in height from 20ft to 200ft. Waveguide feeders of 2in by ½in rectangular cross-section connect the paraboloids to the transmission equipment which is located at ground level.

To ensure a high degree of reliability, all the transmission equipment, other than the waveguide feeders and paraboloids, is duplicated, and supervisory equipment is arranged to provide automatic change-over to the standby equipment in the event of failure of the working equipment. A standby power source is also provided which is started up when the incoming mains fail.

In addition to the automatic change-over arrangements within each station, a signalling system is provided over a land-line circuit to notify the control engineers at the terminal stations of the state of the equipment at each station, and the control engineer at the terminal station can perform various operations on the equipment which is sending the signal to his station.

The provision of the duplicate equipment, with automatic supervision and a remote-control and indication system, allows the system to operate without continuous attendance of the maintenance engineers at all stations.

Supervisory and Remote-Control Arrangements

As this was the first s.f. radio link to be installed in this country, the problem of ensuring adequate safeguards against equipment failure was approached with some caution, and it was specified that all the transmission equipment, other than the waveguide feeders and aerials, should be completely duplicated. A choice had then to be made between running the equipment as two parallel systems with change-over at the terminal stations only, or using the duplicate equipment to replace faulty equipment at the individual stations.

If parallel systems had been used, the remote control and change-over arrangements could have been greatly simplified but double the number of carrier frequencies would have been required. The individual-station switching system requires complicated remote-control and automatic-switching circuits, but inherently provides a far greater degree of reliability on a nine-station system. Against this must be set the increased chance of failure of the more complicated supervisory system. In this case it was decided to use individual-station switching.

Before any action can be taken to change over from a faulty working to a standby equipment, a reliable indication is required that a fault condition has, in fact, arisen. In a repeater equipment these indications are derived from the carrier levels at intermediate and super frequencies in the various parts of the equipment (which are virtually independent of the signal modulation) and the frequencies of the local oscillators in relation to the generated reference frequency. Faults due to failure of valves or components cause a change in the carrier levels or in the a.f.c. circuits, which are registered by the appropriate detectors, and change-over to the standby equipment occurs.

As the detector system depends upon the carrier signals, which are too low in power to be detected directly at the input to a repeater equipment, it is essential to provide some means of identifying whether loss of carrier level is due to loss of input level (because of a fault at a preceding station or a deep fade) or to a fault in the station in question, if false change-overs are to be avoided. Signals could be passed from one station to another (by land line or auxiliary radio link) to inhibit change-over action of successive stations, but the method is complicated and does not provide protection against very deep fades. It was decided that an effective solution of the problem would be to use an auxiliary receiver in parallel with the signal receiver at each station, so that no action is taken on simultaneous loss of carrier in the two receivers.

At the terminal stations the same arrangements are employed as at the repeater in the s.f. and i.f. circuits. Pilot tones at 4 Mc/s and 5 Mc/s are used to monitor the video circuits, because these handle variable-amplitude signals to which simple level-monitoring devices are not applicable.

Automatic change-over occurs whenever there is a fault indication from a detector, provided that the incoming carrier is present and the mains supply has not failed. Each detector is duplicated as a safeguard against failure of the detector, and all detectors are changed over to the new working equipment when a change-over takes place. The whole of an equipment, either repeater, terminal transmitter or terminal receiver, is replaced by the duplicate equipment whenever a fault occurs in any part of it, by the action of waveguide switches. The frequency-generator bays are switched independently. The loss of picture time during a change-over is about two seconds.

In order to reduce the lost transmission time on change-over and yet prolong the life of the non-working equipment, the latter is run with normal heater voltages but reduced h.t. voltages on all the valves. When it is required to replace a faulty equipment, full h.t. voltage is applied as the waveguide switches rotate.

With the detectors which are necessary to ensure fault registration it is possible to indicate within limits the portion of an equipment in which a fault has occurred, and this information is displayed on a local-station indicator board for the assistance of the local maintenance staff.

As it is important to repair a faulty equipment as soon as possible, a remote signalling system is provided which tells the system controller the state of the equipment at each station and gives an alarm whenever a fault occurs. The system controller can then inform the staff at the maintenance centre nearest the faulty station that a fault has occurred.

As a further safeguard against breakdown of the system and in order to perform routine functions such as switching on and off, remote control facilities are provided on the control desk for performing various operations at the individual stations. These controls can be selected for individual stations or, by throwing a "mass" control key, can be operated at all stations simultaneously. The following controls are provided :—

(*i*) To switch power on or off the equipment.

(*ii*) To change over from mains to engine-set supply or vice versa.

(*iii*) To change over to the reserve equipment.

(*iv*) To apply to, or remove power from, a "failed" equipment.

(*v*) To check the condition of any station.

(*vi*) To call any station by telephone.

The control desk is also equipped with a telephone and a picture and waveform monitor showing the received signal.

System Performance

The radio-relay system first carried traffic on an extemporised basis on the occasion of the transmission of pictures of the funeral of His Late Majesty King George VI, on February 15, 1952, and opened for regular daily transmission on March 14, 1952; although the programmes were carried from that date on a regular basis, the work of installation continued and was completed early in 1953, and until that date the system was partially staffed in order to safeguard "engineering working party" faults.

The overall end-to-end signal/noise ratio and performance of the system has been satisfactory, in that no section has faded to below the repeater threshold level (31 db relative to free space on the longest section) and that there has been no persistent deep-level fading on a number of sections of the system. Over a period of one year of approximately 3000 hours of programme operation, the system signal/noise ratio has deteriorated, owing to fading by more than 15 db below its normal value of 41 db for less than 85 sec., i.e. less than 0·001 per cent of the time. The 15-db figure has been selected for this purpose, since 26 db (i.e. 41–15 db) represents the level at which noise becomes just visible under ideal viewing conditions on a high-grade monitor at the system output.

Conclusions

The installation described in the paper was the first permanent broad-band radio-relay system in the s.f. band to be put into public service in this country. The project was conceived not merely as a single isolated system but as a component part of a large national network, with a performance target corresponding to that role. It is therefore appropriate to consider in what measure the planned objectives have been fulfilled and what lessons may be learned for the future.

The equipment has met all the requirements of transmission performance, and over a period of service operation its characteristics have proved very stable. Whilst it is too early to quote specific long-term performance it can already be said there need be no significant difference in the methods of maintenance and operation of broad-band radio and cable systems. The satisfactorily low incidence of fading has fully justified the initial circuit planning which was based upon an average section length of about 30 miles and supported by propagation tests. The worst fading has occurred in the early hours of the day.

The achievement of good impedance matching on long feeder runs proved to be an important factor in performance, since long feeder runs are unavoidable in many cases if the equipment is to be located at ground level. Manufacturing and installation experience showed that this requirement, although difficult, can be met by taking adequate care in design and manufacture.

The aerial-crosstalk trouble experienced at Blackcastle Hill, although slight, emphasised the importance of the detailed arrangement of the aerials and showed that the existence of external objects in the near field of the aerials may give rise to similar effects, even though the objects are not in the direct line of sight. The travelling-wave amplifier proved to be a robust and reliable circuit element.

Further studies need to be undertaken on the all-important aspect of the scale of provision of standby and supervisory facilities, particularly when in future it will be necessary to provide for the transmission over any one route of several r.f. channels which may be used for television or multi-channel telephony. The need to reduce to a minimum the amount of duplicate and supervisory equipment has to be balanced against the need to provide adequate protection against multiple faults, particularly where access may be difficult to unattended stations. It will therefore be necessary to study carefully the relative merits of reserve-channel versus reserve-equipment provision. At present the authors take the view that no general doc-

trine can be formulated, but that the method of provision and the level of security required will depend on the local conditions.

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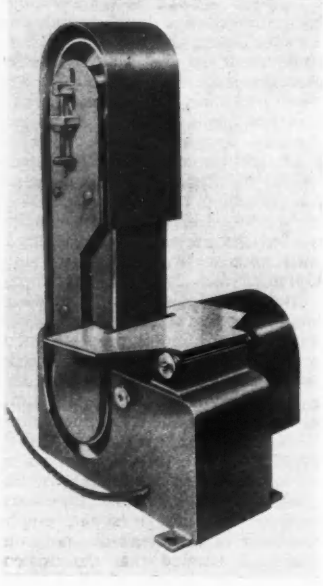
Finishing Machine for Carbide Tools

AN abrasive belt machine specially intended for imparting a high finish on single-point tipped carbide tools is now being made by B. O. Morris, Ltd., Briton Road, Coventry. As can be seen from the photograph we reproduce below the belt is arranged vertically on this machine. Tools during the finishing operation are supported on a table of convenient size which can be tilted 15 deg. above and 7 deg. below the horizontal. The endless silicon carbide belts used on the machine are 54in long by 4in wide, and are supplied in grades from 150 down to 600 grit. The belts are driven by a ½ h.p. totally enclosed motor at a speed of 4500ft per minute, and they can quickly and easily be changed.



Finishing Machine for Single-Point Tipped Carbide Tools

Before being finished on this machine the makers state that tools should first be rough ground on green grit silicon carbide wheels at an angle about 3 deg. greater than the required relief angle. The work rest of the finishing machine having been set to the required angle, the tools are then passed across the belt several times and, dependent upon the angle, this gives the high finish to a depth of about $\frac{1}{10}$in.

Gas Turbine Component Manufacture

NOTWITHSTANDING the investigations which have proceeded for the past several years to establish the most suitable production techniques for certain aeronautical gas turbine components a number of issues have still to be resolved. The most fundamental of these concerns blading production, and both here and in America there is still some doubt as to whether the aerofoils of stamped or forged blades are best produced in dies as precision stampings or, alternatively, as rough stampings subsequently machined to size. The Ministry of Supply is consequently still studying all promising manufacturing processes in both fields with the object of determining which is the cheapest and, at the same time, safest to adopt from the point of view of quick expansion in emergency, i.e. the least exacting from a skilled labour angle.

A particular argument in favour of precision stamping is that the machining effort consumed (e.g. the "Ex-Cell-O" method) in milling and grinding the aerofoils of individual blades would be better expended in the manufacture of dies which, in turn, could reasonably be expected to produce say, 1000 steel or 3000 light alloy blades within U.K. drawing limits between each recutting stage.

In the opinion of the Ministry of Supply a great deal can be said for this viewpoint, particularly now that a lot of the work connected with die manufacture and subsequent reconditioning has been simplified, but the high production rate obtainable when stamping blades to wider limits for subsequent machining, coupled with much longer die life is also very attractive. In consequence, rough stamping and machining of blades is being given a thorough trial on a production scale with the object of proving which is the cheaper of the two methods. A concerted effort is being made to reduce the skilled labour element in blade die manufacture since this will yield a dividend whichever method of stamping (precision or rough) is employed, and some success has already been gained in this direction.

Dies.—Some American blade firms claim a die life considerably in excess of ours, and while this can be accounted for mainly by the wider manufacturing tolerances allowed on American blades, there are still matters of detail to be investigated and resolved. Reliable data have been collected showing the die steels used in the United States, heat-treatments and protective processes employed during hardening and tempering, die lubricants, operating temperatures, &c. Details have been conveyed to leading stampers in this country for comparison with their own techniques and subsequent trial.

To cheapen die sinking full use has been made of the fairly recent production expansion scheme, introducing multi-spindle improved die sinking machines, ground-tooth tungsten carbide cutters, burrs, &c. Similarly, new means of "finishing" dies after machining have been introduced, amongst which are small diameter flexible abrader discs, together with high-speed rotating and oscillating head type hand tools.

The Directorate of Aircraft Production Development has been experimenting with two forms of finishing tools developed in America for use on fine limit dies. The most successful has been the flexible abrader discs which are supplied already treated with a rubber solution adhesive on the non-grit face and can be quicky fixed to a flexible rubber rotary carrier by the operator. The abrader discs are now being made here and will reduce considerably the man-hours expended in finishing aircraft components and dies.

The "Diprofil" electrically operated hand finishing machine is another machine which has been adopted for die finishing.

This machine, driven through a flexible drive shaft by a high-speed electric motor, uses either rotary or oscillating tools.

The rotary speed is in the region of 10,000 r.p.m.; the oscillating attachment, which embodies an adjustable stroke ranging from zero to ¼in, operates at 7000 cycles per minute. A wide variety of tungsten carbide cutters, riffling files, diamond impregnated tools, &c., can be used with this machine.

Electro-erosion machining is a process which has been applied very effectively in die sinking and recutting of hardened dies, the process having been described in THE ENGINEER, March 7, 1952.

As the name implies, metal removal is by spark or arc erosion, the workpiece and electrode (cutting tool) being submerged in a fluid—usually paraffin. The electrodes are generally speaking made of brass; they can be of a wide variety of shapes both in section and surface contour; drilling, for example, can be done in almost any shape, e.g. round, square, oval, &c., and in consequence the manufacture of piercing or extrusion dies for complex shapes becomes a relatively easy matter. The rate of metal removal largely determines the degree of "finish" obtained by this process. The man-hour element, however, is negligible, since the electro-erosion machines are designed to be automatic in action once the rate of feed has been selected.

Percussion machining (known as "Cavitron" in America) also serves usefully in this field, and has the additional advantage that it can be used on non-conductor materials. Reference was made to a tool based on the principle by Mullard, Ltd., in THE ENGINEER, April 24, 1953. With this method a transducer is employed to vibrate the tool which operates through the media of boron-carbide crystals suspended in a liquid. The shape of the cavity thus mechanically eroded conforms in both section and contour to the shape of the tool. The finish obtained is excellent and in many applications it is a faster technique. In cases of dies made from tungsten carbide blocks having a sintered hole by the diamond lapping method which normally took several weeks to produce can by this method be made in a few hours.

Defects with Stamped Blades.—Minor surface imperfections liable to occur during stamping (which are normally removed in the case of machined blades) can become a serious source of fatigue failure in the case of precision stamped blades. Most careful inspection during the several stages of stamping is therefore necessary, and this involves problems in training inspectors not to mention high consumption of man-hours. Since there are approximately 2000 blades per compressor in axial-flow turbines it is clear that several million blades per month may require this detailed examination in an emergency.

This high man-hour element makes a drift in design towards rolled and twisted steel aerofoil section blades for stators attractive from the production angle. Similarly, hollow formed blades cannot be overlooked, be they either rolled extruded or made from tube; but these are matters which involve design considerations also.

There is another school of thought of the opinion that turbine compressor blades can be formed quickly and accurately by hot rolling and that the life of the roll will greatly exceed the life of forging dies, and this process is being investigated. To ensure thorough exploration of all likely improvements in blade production methods, a Blade Manufacturing Panel of the Gas Turbine Collaboration Committee, Manufacturing Sub-Committee has been formed. Each of the aero-engine firms and D.A.P.D. have a representative regularly serving on this panel.

TORSION CONSTANTS FOR BULBS AND FILLETS.—We have received from the Aluminium Development Association, 33, Grosvenor Street, London, W.1, a copy of Research Report No. 22, *The Determination of Torsion Constants for Bulbs and Fillets by Means of an Electrical Potential Analyser*, price 7s. 6d. This report describes an electrical potential analyser and its application in determining torsion constants of bulbs and fillets, together with some account of the operation of the apparatus, which is analogous to the mathematical relaxation process. The mathematics of the torsion problem are briefly outlined and the test results for three kinds of fillet in an angle section, tee junction and single and double-sided bulbs, together with two shapes of fillet in acute angled sections, are given graphically and also in tabular form. The accuracy of the potential analyser is shown by including a comparison between relaxation and electrical solutions which indicated a difference of only 1 or 2 per cent.

Atomic-Powered Submarine

(By Our American Correspondent)

THE launching of the U.S.S. "Nautilus" into the Thames River at Groton, Connecticut, last month was an event of historic importance. By virtue of its atomic power plant, this submarine is destined to change naval warfare and to give sea power a new significance. She is, indeed, as Admiral Robert B. Carney, the Chief of U.S. Naval Operations, said in the address he delivered at the launching: "A symbol of man's outreaching imagination, his willingness to embark on a Jules Verne voyage over the hazy horizons and the imaginative future." Compared with the undersea boats of the past, which had to come to the surface after limited periods of submergence, the "Nautilus" may be considered to be the world's first true submarine. The atomic power plant will enable her to voyage submerged for 30,000 miles at 20 knots. Silently will she slip through the water, with no exhaust bubbles, no wake, no throbbing internal combustion engines and no batteries, except on the rare occasions when an emergency diesel-electric engine must be employed. In its effort to develop atomic energy as a source of power for transport purposes, the United States decided to concentrate on an atomic-powered submarine, because submarine propulsion had always been a problem. In August, 1951, the U.S. Navy awarded a contract to the Electric Boat Company to build "the first nuclear-powered submarine." A year later, President Truman went up to Groton for the keel-laying ceremony. Then, on January 21st last, Mrs. Eisenhower christened the submarine "Nautilus" and the hull was launched. According to present schedules, the "Nautilus" will be ready for her trials in about six months, while her sister ship, the "Sea Wolf," is at present still on the ways at Groton. Though the two vessels will resemble each other outwardly, there will be a difference in their power plants. In the "Nautilus" the reactor heats pure water which then goes to a heat exchanger to generate steam; in the "Sea Wolf" the medium of heat transfer is molten sodium.

For some time now the design and construction of both these vessels has been causing much controversy in American naval and marine engineering circles. While the launching of the "Nautilus" without doubt marks the start of a new era in naval propulsion, it would be premature to assume that the age of nuclear ship propulsion has now arrived. The present developments do not justify the wholesale conversion of the world's naval and merchant fleets to atomic propulsion; indeed, costs and other limitations indicate that for some time to come atomic propulsion will be utilised chiefly for only a few specialised naval vessels. From a cost point of view atomic power plants cannot compete to-day with oil engines, and both gas turbine and high-pressure, high-temperature steam installations promise greater economy, with none of the specialised problems that will complicate the operation of the "Nautilus." Some of the superlatives that have been linked to the "Nautilus" and the "Sea Wolf" are, nevertheless, justified. Each vessel will displace, contrary to prior reports, considerably more than 3000 tons, which will make them among the world's largest submarines. The speed of the atomic submarine will be greater than that of any other United States submarine, probably between 20 and 28 knots. The atomic fuel of the "Nautilus" will take her around the world without refuelling, and her underwater cruising endurance will be limited chiefly by the endurance of her crew of about ninety officers and men. These characteristics are the greatest potential military advantages of the atomic-power submarine. The normal submarine has underwater speeds considerably slower than those of faster surface ships. It can overtake fast convoys only by surfacing where it is exposed to radar detection and attack. The speed of the "Nautilus," underwater or surfaced, should be ample to enable it to keep pace with all except the world's fastest vessels.

The U.S. Navy has realised that human endurance rather than mechanical considerations are likely to limit the maximum period of submergence of the "Nautilus." When a crew does not know whether it is in the Indian Ocean or under an ice floe at the North Pole without consulting the log, when there is no day or night, when the same stories are told over and over again and the same eccentricities annoy day after day, naval staff officers wonder how long nerves can stand the strain. For these reasons life will be made as pleasant as possible on the "Nautilus." Her bunks are comfortable and the upholstery is pleasant in design and colour. Naked bulbs have been replaced by soft agreeable illumination. Though the best use must be made of every cubic foot of space, the quarters for relaxation have a roominess that we associate with clubs rather than submarines. There are ping-pong tables, a film projector, a gramophone and that American institution—the "juke box"! The crew's air supply will be freshened by air-purifying apparatus, by oxygen bottles and by special devices, still under development, that will manufacture oxygen from sea water. But these assets are qualified by some major limitations. Since the "Nautilus" is the first vessel to be driven by atomic power, it was felt advisable, as a safety factor, to parallel her atomic power plant with a conventional diesel and electric battery installation, thus complicating operation and increasing costs. Her initial construction cost of about 55,000,000 dollars, including the engine, is about three times the initial cost of a conventional submarine. Her operating cost will be considerably higher, since her crew is about 10 per cent larger than that of the standard American submarine and since she utilises expensive atomic fuel. Whether or not the "Nautilus" can be considered a combat submarine depends on events. If general war came to-morrow she would probably be used in combat operations. But her real value is as an experimental prototype of possible fleets of the future.

American Engineering News

(By Our American Correspondent)

Revised Iron-Constantan Thermo-Couple Tables

A new set of reference tables for iron-constantan thermo-couples, which have recently been prepared by the National Bureau of Standards, cover a range from −310 deg. Fah. to +1600 deg. Fah. and have been found to correspond more closely to the properties of commercially available thermo-couples than do any of the other iron-constantan reference tables currently in use in the United States. The N.B.S. tables are based on an investigation carried out at the request of the Scientific Apparatus Makers of America (S.A.M.A.) and have been recommended by this organisation for adoption as a tentative standard. For the measurement of temperatures up to 1500 deg. Fah., the iron-constantan thermo-couple is to-day widely employed in America, and yet it is the only type of thermo-couple for which uniformity of commercial practice has not yet been established. Because such a small proportion of the total production of iron goes into thermo-couples, the manufacturers of pyrometers find it more economical to select suitable lots from available commercial iron than to have iron prepared to specifications applicable especially for thermo-couples. As a result, a number of widely diverse reference tables have been used for iron-constantan thermo-couples. Also, from time to time, changes in the composition of commercial iron being produced in the United States have made these tables less representative of the iron thermo-couples which are in actual use.

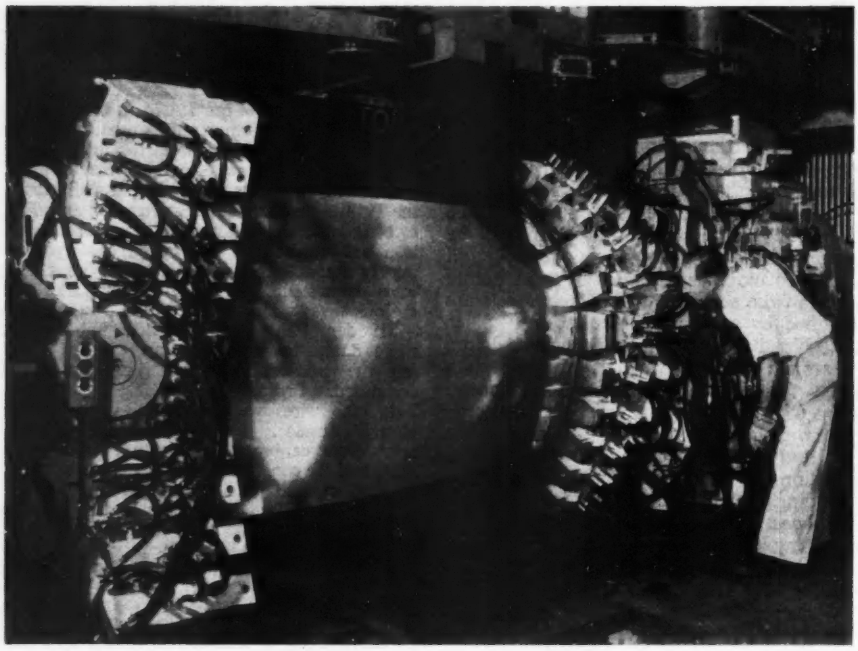
In 1948 the Scientific Apparatus Makers of America, representing several of the American pyrometer manufacturers, adopted the temperature-e.m.f. relation known as the 1913 (Leeds and Northrup) table as a tentative standard for iron-constantan thermo-couples over the range from 32 deg. Fah, to 1400 deg. Fah. This relation was chosen because it was in wider use than any other. However, experience has shown that it has not been possible to produce a thermo-couple from present-day commercial iron that will correspond precisely to the 1913 table. Furthermore, any thermo-couple which closely matches this table in the range below 1400 deg. Fah. has been found to deviate greatly from it in the range above 1400 deg. Fah. A further difficulty was the fact that the original 1913 table did not extend below 32 deg. Fah. The S.A.M.A., therefore, requested the National Bureau of Standards to derive a reference table that would be as close as possible to the 1913 table yet would be free from these defects. Each member firm of the S.A.M.A. that supplies iron-constantan thermo-couples was invited to submit sample thermo-couples for investigation at the Bureau. These samples were to be of commercial materials selected to match closely the 1913 table over the range from 32 deg. Fah. to 1400 deg. Fah. Eight different lots of matched iron and constantan wires of a size approximately equal to No. 8 American Wire Gauge were submitted. The thermal e.m.f. of the various wires were measured over a range from −319 deg. Fah. to +1800 deg. Fah. From these data, the corresponding thermal e.m.f. for the iron-constantan thermo-couples was computed. From 32 deg. Fah. to 1800 deg. Fah., the wires were calibrated in a tubular electric furnace. For convenience, the iron wires were calibrated against a standard iron wire, and the constantan wires against a standard constantan wire. The standard iron and constantan wires had previously been calibrated against "Pt 27," the platinum thermo-electric standard of the N.B.S., and they were rechecked at frequent intervals during each run against the platinum element of the platinum versus platinum-10 per cent rhodium thermo-couple which was used to measure the temperature. Because of the relative instability of the iron and constantan at temperatures above 1400 deg. Fah., measurements in this range were made against a platinum standard only. From 32 deg. Fah. to −319·5 deg. Fah., the thermal e.m.f. of each wire against a copper reference wire was determined in stirred liquid baths. The copper reference wires were calibrated against a platinum standard. Down to −147 deg. Fah., use was made of a special cryostat developed at the Bureau, which automatically maintains a constant temperature in a stirred liquid bath. Observations were made at two lower temperatures by use of baths of liquid oxygen and nitrogen stirred by a stream of the same gas. The temperatures in these baths were determined with a platinum-resistance thermometer. Tables giving the temperature-e.m.f. relations for the individual iron and constantan wires relative to the platinum standard at the various calibration temperatures were compiled, and these data were then combined to give the corresponding relationships for the complete iron-constantan thermo-couples.

As a result of this work the S.A.M.A. has recommended the adoption of the temperature-e.m.f. relationship of one of the thermo-couples studied as a standard to replace the 1913 table. The particular temperature-e.m.f. relationship selected deviates least from the 1913 table in the range of normal use. The upper limit of the tentative standard has been set at 1600 deg. Fah. because of the instability of the iron-constantan thermo-couple above this temperature and also because of the large increase in

the deviation of the thermo-couples tested by the N.B.S. from each other above this temperature. In the course of the investigation, the Bureau invited suggestions from industry as to whether the new temperature-e.m.f. relationship would be acceptable as a standard, and the replies received were uniformly favourable. The tables giving the new temperature-e.m.f. relationship for both Fahrenheit and Centigrade scales have been published as research paper 2415 in the *Journal of Research of the National Bureau of Standards*, Vol. 50, page 229.

Flexible Jaws for Sheet Stretch-Forming Machines

The accompanying illustration shows a set of flexible jaws which has been designed for use on sheet stretch-forming equipment and is made by the Hufford Machine Works of El Segundo, California. Known as the "Hydra-Curve" jaw, its function is to grip and curve the sheet to the cross sectional contour of the die. While held in this profile, stretch-forming then completes the longitudinal curves of the part. As compared with straight, rigid jaws, the use of the flexible jaws is said to save as much as 30 per cent of material which is normally allowed for beyond the ends of the die to accommodate the transitional stresses in the sheet. The new jaws are claimed to simplify the formation of all parts with less wrinkling and to permit the formation of exceedingly deep curves by the stretch-forming process. The flexible jaws are composed of numerous segments, each containing a set of hydraulically actuated grippers. The segments are hinged one to another by pivot pins and can thus conform to a wide variety of die curves. The degree of curvature is established by adjustable set-screws, which act as fixed stops in front of and behind each segment. The jaw curvature is energised or straightened by a pair of hydraulic cylinders in each segment which are controlled from the operator's pedestal. The jaws are always loaded in a straight-line position; they are curved just before or during the stretch-forming operation. To centralise the load of a curved shape to the tension cylinder shaft, a centroid shifter is provided. This is essentially a slide on which the jaw is mounted, permitting its position to be shifted laterally by a hydraulic cylinder or screw. The jaw elements consist of two removable grippers in each segment, which are serrated for holding the work, and which slide on opposed tapers. Although the jaw grippers are opened or closed by a hydraulic cylinder, the gripping action is self-energised by the taper as soon as tension is applied to the sheet to be stretch-formed.



Stretch-Forming Machine Employing Flexible Jaws

Reorganisation of the U.S. Bureau of Reclamation

The U.S. Secretary of the Interior has now announced the approval, with some modification, of the recommendations of a survey team which, during the last two months, has investigated the organisation and operations of the Bureau of Reclamation. The recommendations and their implementation are largely intended to bring about a decentralisation of planning, construction and operation activities of the Bureau to the greatest degree possible in order to permit closer co-operation with the water users. The office of the Reclamation Commissioner in Washington will in future be concerned mainly with matters of policy, administration, liaison with the U.S. Congress and other governmental agencies and such essential services as may be related to these subjects. The technical phases of operation and maintenance, project planning and design and construction will be centred in the Denver office of the Bureau. Denver has for a long time been the centre of engineering operations of the Bureau and is in the heart of the area served by it. The chief engineer, who has in the past headed the branch of Design and Construction in Denver, will be promoted to the rank of Assistant Commissioner in charge of all staff activities there. Two assistant commissioners will be situated in Washington.

All six existing regional offices will be retained and the California Projects office at Sacramento, California, will be restored to regional status. The present regional offices are at Boise, Idaho; Boulder City, Nevada; Salt Lake City, Utah; Amarillo, Texas; Billings, Montana; and Denver, Colorado. The survey team recommended that the regional administrative organisation be retained but that the Missouri Basin regions Six and Seven, at Billings and Denver, respectively, be combined. The Department found that this merger was not practical at this time because a change in boundaries would unnecessarily disrupt the extensive schemes which are being carried on at present. District offices, as now constituted, are to be eliminated, as recommended in the report. However, it is recognised that these district offices are now situated at focal points and that, in general, it will probably be necessary to establish so-called project or consolidated project offices at the same locations. There are no plans for the immediate abolition or relocation of any field offices.

The Commissioner of Reclamation has emphasised that the survey report does not seek any further reduction in personnel except for such reductions which can be made by the elimination of duplicating or unnecessary functions. The Bureau of Reclamation has reduced its staff by 2175 persons in the last six months and at present has 10,909 employees. This reduction was made to conform with the current economy policy of the Eisenhower administration.

Indian Engineering News

(By Our Indian Correspondent)

Tungabhadra Dam

The Tungabhadra project, a joint multi-purpose enterprise of Madras, Hyderabad and the new Andhra States, is well on the way to completion, and the first issue of water for irrigation on the Madras side was made in September. The scheme, estimated to cost Rs. 35 crores (£26,000,000), consists of a 150ft high dam, impounding a reservoir with a gross capacity of about 2,600,000 acre-feet, two irrigation canals totalling 352 miles in length, and irrigating 1,940,000 acres, and a small power station with a capacity of about 30MW in the first stage. The dam cost over Rs. 15 crores and was completed in October last, after nearly eight years of work.

At the dam site the Tungabhadra River, a tributary of Krishna, has a catchment area of 10,880 square miles. The dam, a solid gravity structure, has a maximum height of 160ft above the deepest foundation level, and impounds a reservoir with a water spread of 133 square miles extending over 100 miles upstream, submerging sixty-five villages and lands situated in the four states of Madras, Hyderabad, Bombay and Andhra. The reservoir will feed two irrigation canals: the Hyderabad canal, 127 miles long, will irrigate 1,080,000 acres, and the Madras canal, 225 miles long, will irrigate 860,000 acres, both yielding 140,000 tons of food crops and 80,000 tons of commercial crops, mostly cotton.

The total length of the dam is 7942ft, divided into four sections, consisting of 3642ft of masonry dam in the non-spillway portion, 2300ft in the spillway, a rolled-earth fill dam for 450ft in the first saddle on the left flank, and a composite dam 1500ft long in the second saddle. In the construction of the dam extensive use is made of surki, powdered brick (THE ENGINEER, July 3, 1952), which, besides improving workability, reduces the heat of hydration and helps to keep down the cost of construction. The spillway section is built with granite stones in cement mortar 1 : 4, 20 per cent of cement being replaced by surki. A richer mix of 1 : 2·75 is adopted for the front 9ft to improve water-tightness. The non-spillway sections have been built in granite stones in lime-surki mortar, the proportion being one lime, one surki and one sand. Sections having sluices and penstocks are in red cement mortar of 1 : 4 up to a level of 48ft and 1 : 5 above that height. The composite construction used for the higher of the two low-level saddles consists of a masonry wall in front with earth backing in the rear. The wall is built in the same way as the main masonry dam with foundations taken to the rock. The earth backing is of semi-pervious material with a slope of 2 to 1 on the downstream side, horizontal berms being left at suitable intervals.

The Madras canal on the right flank is fed by ten high-level sluices, 6ft by 12ft, built 75ft above bed level, discharging 2500 cusecs. The canal has a bed width of 72ft and, at the full supply depth of 10½ft, the flow has a velocity of 3ft per second. The Hyderabad canal, with a capacity of 7000 cusecs, is much larger. The canal is 84ft wide and the flow at the full supply depth of 14ft has a velocity of 4·5ft per second.

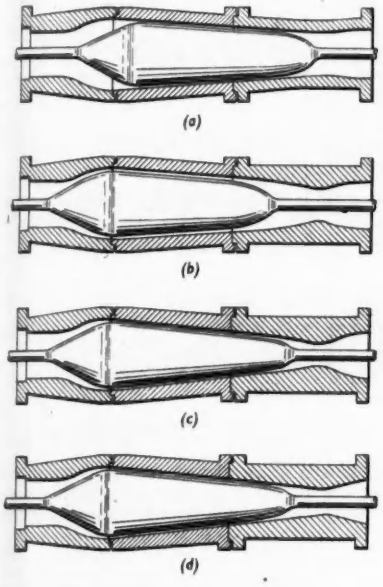
The hydro-electric part of the project is in the initial stage, as, owing to the scarcity conditions in the locality, priority had to be given to the irrigation side. The Tungabhadra dam is the first major masonry dam to be completed in India since the war. The chief engineer was Mr. M. S. Thirumale Iyengar, who has since been transferred to the Hirakud project which is now in an advanced stage of construction.

Some Model Experiments on Special Control Valves

By D. FIRTH, A.M.I.Mech.E.,* and LESLIE YOUNG†

No. II—(*Concluded from page 209, February 5th*)

Valve Type 3.—The necessity for operation free from fluctuations in pressure or flow was of particular importance in the case of valve Type 3, since it was to form part of a closed-circuit rig where the masses and volumes available for damping would be relatively much smaller than in the other applications dealt with in this paper. Freedom from cavitation over a wide range of working conditions was also essential if full use was to be made of the pump testing facilities provided by the rig. The best way of meeting these requirements appeared to be to design a valve in which energy was dissipated by friction at solid boundaries, so that the characteristics of the valve could be altered by varying the shape of these boundaries. It was known that a valve of this type had been successfully employed at the California Institute of Technology (Knapp and others, 1948), though the range of conditions covered was very much smaller than that occurring in the closed pump research rig. Because



a—Model 1, 8 deg. included angle cone.
b—Model 2, 8 deg. included angle cone.
c—Model 3, 12 deg. included angle cone.
d—Model 4, 12 deg. included angle cone.

Fig. 11—Model Valves Type 3

no information was available for the design of such valves, it was decided to undertake a programme of model tests, from the results of which a suitable form for the full-size valve could be determined. A preliminary study suggested that it would be advantageous to employ two valves in series rather than to attempt to cover all the conditions with one valve, and the work was therefore planned with this in mind.

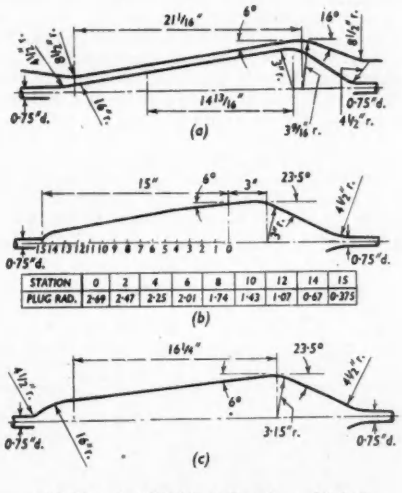
An arrangement was chosen for test which consisted essentially of a long tapered plug which could be moved axially in a similarly shaped body. The taper was such that the diameter of both plug and body increased in the direction of flow, and suitably shaped contractions were provided to lead fluid into and out of the valve. The flow was thus directed through an annular passage of constantly increasing area for the major part of the valve length, and the dimensions of this diverging annular channel could be varied by moving the plug relative to the body. Four designs were prepared, two based on a taper of 8 deg. on diameter for plug and body, and two on a taper of 12 deg. Fig. 11 shows the proportions of these valves. They were manufactured with Perspex bodies and aluminium plugs, of a size suitable for use in a pipeline 1in in diameter. Each of the bodies was provided with numerous static pressure tappings throughout its length. The movement of the plugs was controlled by a micrometer screw, from which the valve opening could be determined.

The overall pressure drop and the static pressure distribution through the model over the full range of plug travel were measured. The corresponding flow rates were given by the Venturi meter readings or obtained by weighing. As a check on these results, the location of the points of lowest pressure in the valves at various plug settings was found by connecting the system through a water trap to a vacuum pump and lowering the absolute pressure. Bubbles, which appeared first in the regions of lowest absolute pressure, could be clearly seen through the Perspex valve bodies, and their positions noted. Confirmation of the previous observations was obtained.

These experiments on small models yielded valuable information on the performance of the valves. In order to investigate possible scale effects it was decided to proceed to a second stage with models suitable for installing in a 4in diameter line, giving a scale reduction of 1/4·5 from the proposed full-size valves. These larger models were constructed to designs prepared from the results obtained from the previous experiments, and they were erected in the test house at Kilmarnock. Three assemblies were tested, designated models 5, 6 and 7. In each case the body was the same, the variations being made in the shape of the plug. These models are illustrated in Fig. 12.

Considerable trouble was experienced in the early stages of testing from vibration of the plug. This was so violent on occasion as to cause fractures of the guiding bushes and of the valve rod. The method of support used was clearly inadequate to prevent the system from being excited by the small pulsations in flow and pressure present in the discharge from the pump. This was overcome by providing guides brazed to the valve body so placed as to operate against the maximum plug diameter. Once these had been fitted the vibration was completely eliminated, and the tests could proceed. There was one unfortunate consequence, however, which was the loss of a comparison between the performance of model 5 with a smooth and with a rough surface on plug and body, as had originally been planned.

When the experiments involving observations



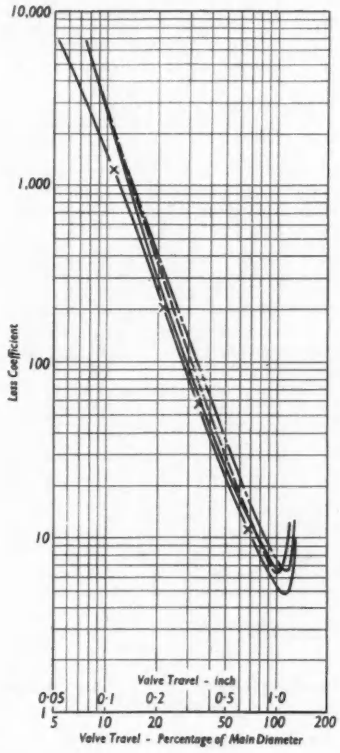
a—Model 5. *b*—Model 6 ; body as 5. *c*—Model 7 ; body as 5.

Fig. 12—Control Valve Type 3 ; 4in Models

of pressure and flow on model 7 had been completed, an attempt was made to confirm the results by inducing cavitation in a manner similar to that employed for the valves 1in in diameter. For this purpose a centrifugal pump driven by a variable-speed motor was coupled to the outlet of the valve, so that the absolute pressure in the valve could be reduced over a wide range by varying the pump speed. By applying a stethoscope to the valve body it was hoped to detect aurally the onset of cavitation, but the method proved to be insufficiently selective.

The results of the experiments on all seven models of valve Type 3 are shown graphically in Figs. 13–15, where the overall loss, a typical pressure distribution, and the cavitation performance are given in each case. Pressures and pressure differences have been divided by the dynamic pressure in the main pipe (based on mean velocity) to reduce them to non-dimensional form, whilst valve travel has been expressed in terms of the main pipe diameter. Logarithmic plotting has been adopted for the loss coefficient and cavitation performance graphs, both because of the very great range to be covered and because it permits of easier comparison of performance.

It will be seen from Figs. 13 and 14 that the rela-



a—Models 1, 2, 3 and 4, 1in in diameter
—— - —— Model 1. — — — — Model 3.
— x — x — Model 2. ———— Model 4.

Fig. 13—Control Valve Type 3. Loss Coefficients for Models 1 to 4

tion between loss coefficient and valve travel was roughly similar for each model, with the exception of No. 6. This was the only one of the seven tested in which the plug did not "mate" with the body for the greater part of its length. The variation in minimum loss coefficient between the models is due to differences in the lengths of plugs relative to bodies. The body length was constant for models 1, 2, 3, and 4, but the length of the plug in model 2 was less than in the others and a lower minimum pressure loss was obtained. Because the minimum pressure loss of the valves of 1in in diameter was considered too great, the ratio of body to plug length was increased in the 4in diameter models. A reduction from 6·5 to approximately 1·0 in the minimum loss coefficient was achieved with models 5 and 6, and to 2·5 in the case of model 7, which had a longer plug than the other two.

The differences between the various model designs became apparent when the cavitation performance is considered. This has been expressed in Fig. 15 by plotting in non-dimensional form the difference between the valve outlet pressure and the observed minimum pressure in the valve against loss coefficient.

The valve with the best cavitation performance is obviously the one which can be used with the lowest outlet pressure for a given overall pressure drop, and this will be the valve which gives the

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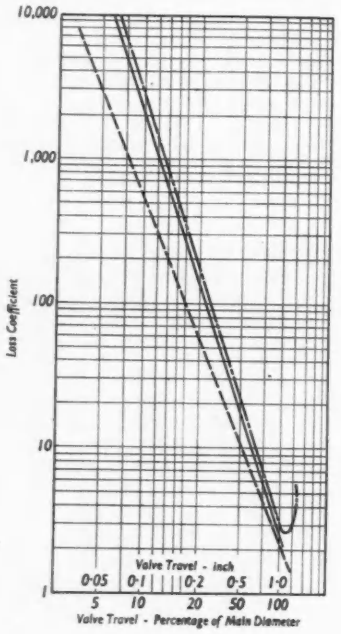
† Scientific Officer, Fluid Mechanics Division, Mechanical Engineering Research Laboratory.

smallest ordinate for a given loss coefficient on a graph in the form of Fig. 15. It was decided that a valve design would be considered suitable if the two valves could be used in series to dissipate 350 h.p. with flow rates varying from 5 to 20 cubic feet per second without the pressure at any point in either valve being more than 10ft of water below the outlet pressure for the second valve.

The discontinuities in the graphs of Fig. 15 are due to the fact that the minimum pressure did not occur at the same place in the valve for all valve openings. Examples of the pressure distribution curves on which the graphs were based are given in Fig. 16. It is not suggested



Models 5, 6 and 7, 4in in diameter.
—— - —— Model 5. — — — — Model 6.
—— - —— Model 7.

Fig. 14—Control Valve Type 3. Loss Coefficient for Models 5 to 7

that the sharp discontinuities in pressure shown in some of the curves actually existed in the valves, but since the number of pressure tapping points in the valve bodies was limited by practical necessity, it was not possible to follow precisely the variation in static pressure, and the graphs have been drawn to give a fair representation of the observations. The magnitude of the minimum pressure indicated at these " sharp points " has been checked by the method of analysis given below to ensure that a true value is indicated, though the actual variation in pressure very near the points will not be exactly as shown.

The best performance of the models 1in in diameter was obtained from model 3—a gratifying result, since the body was of a straight taper form comparatively easy to manufacture. It did not, however, reach the desired standard. The deficiency lay in the range of loss coefficients between 10 and 100, which corresponded to a valve position where the points of lowest pressure in the valve occurred near the plug nose. The design of models 5, 6, and 7 was therefore undertaken with a view to increasing the pressure in this region. This was attempted by two alterations : first, an increase in the ratio of minimum body diameter to pipe diameter, and secondly, by using in place of the elliptical plug nose of model 3 a circular arc profile for models 5 and 7 and a plug based on a cubic curve for the greater part of length in model 6.

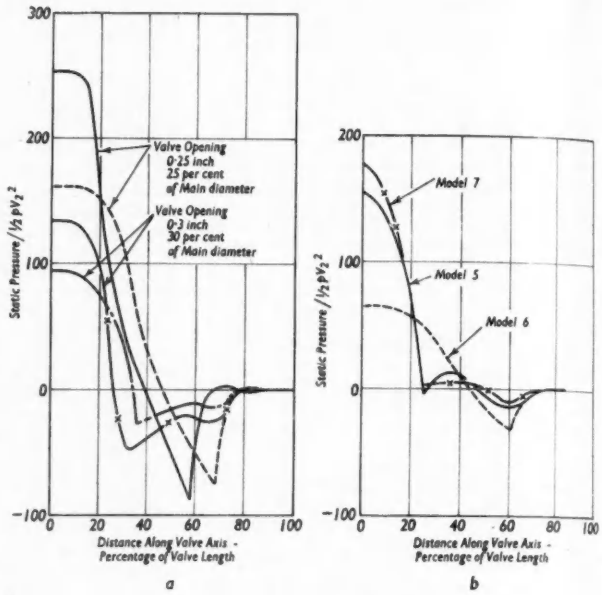
The results obtained can be seen in Fig. 16*b*. The success obtained in reducing the minimum loss coefficient was not repeated for cavitation performance. Model 5 showed no improvement over model 3 in the critical region. Model 7 did give better results, but the difference was small and was not sufficient to meet requirements. In model 6 the low-pressure zone at the plug nose had been eliminated, and at the same valve opening the minimum pressures in this valve were higher than in 5 and 7. Unfortunately, the loss coefficient was much lower, with the result that the cavitation performance at a given loss coefficient was worse than that of the other two models. It was thus evident that further modifications to the design would be necessary to attain the desired standard of performance. A review of the results showed that it should be possible to calculate the required changes from the information already obtained, and an estimate for the performance of a valve so modified was prepared. This is shown in Figs. 15*b* and 17.

Analysis of Results for Valve Type 3.—The results of the model tests can be interpreted by a simple analysis on which the calculations for the final design were based. Using the notation shown on the diagrammatic view of the valve given in Fig. 18, then Bernouilli's equation for points within the valve length L may be written as follows :—

$$\frac{p_1}{\rho}+\frac{\alpha V_1^2}{2}=\frac{p_x}{\rho}+\frac{\beta V_x^2}{2}+E_x$$

$$=\frac{p_2}{\rho}+\frac{\gamma V_2^2}{2}+E_2$$

where E_x is the energy loss between the inlet and section x, E_2 the energy loss between inlet and outlet, and α, β and γ are coefficients correcting



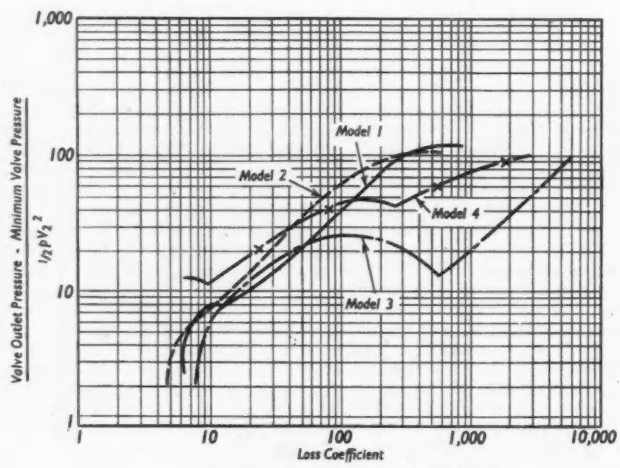
a—Model valves 1 and 2, 1in in diameter.
——— Model 1. — — — — Model 2.
Model valves 3 and 4, 1in in diameter.
—— - —— Model 3. —— x —— Model 4.
b—Model valves 5, 6 and 7, 4in in diameter.
Valve opening 1in ; 25 per cent of main diameter.
——— Model 5. — — — — Model 6.
—— x —— Model 7.

Fig. 16—Control Valve Type 3. Typical Pressure Distribution

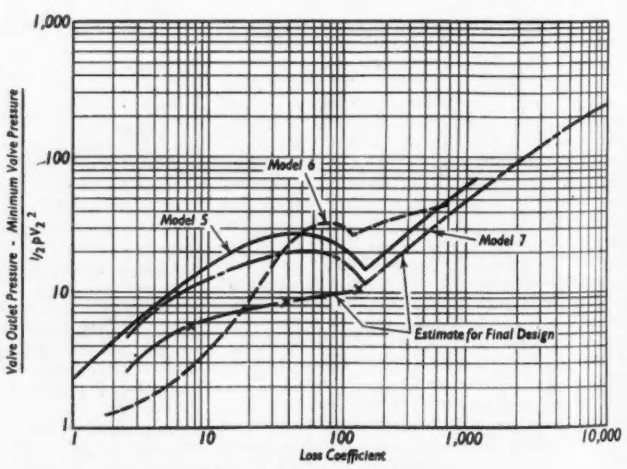
the kinetic energy based on mean velocity to that corresponding to the true velocity distribution. Rearranging and writing $\varepsilon=\beta/\gamma$ gives

$$\frac{p_2-p_x}{\frac{1}{2}\rho V_2^2}=\gamma\left(\varepsilon\frac{A_2^2}{A_x^2}-1\right)-\left(\frac{E_2-E_x}{\frac{1}{2}V_2^2}\right) \quad . \quad . \quad (1)$$

The expression $p_2-p_x/\frac{1}{2}\rho V_2^2$ is the quantity which is plotted as ordinate in Fig. 13, while $E_2/\frac{1}{2}V_2^2$ is the loss coefficient. In valves of the type discussed here, the greater part of the energy loss may be expected to occur in the diverging annular passage at small valve openings. Consequently, E_2-E_x will be much greater at the nose of the plug than at the point of maximum diameter. With small angles of taper the change in the value of A_2^2/A_x^2 from the beginning of the annular



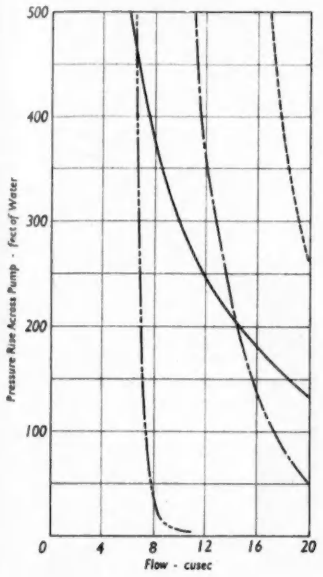
a—Model valves 1, 2, 3 and 4, 1in in diameter.



b—Model valves 5, 6 and 7, 4in in diameter.

Fig. 15—Control Valve Type 3. Cavitation Performance

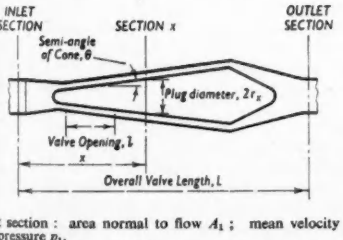
passage to the end will not be very great. It is therefore concluded that the point of lowest pressure will be located at or near the maximum plug diameter when the valve opening is small, and this conclusion is borne out by the experimental results. To illustrate this argument it was found that with a valve opening of 10 per cent of the main diameter, the value of E_2-E_x varied by about 20 to 1 from plug nose to maximum diameter, while the corresponding variation in the value of A_2^2/A_x^2 was approximately 4 to 1 for the 12 deg. taper models and 2 to 1 for the 8 deg. (assuming ε to be constant



——— Power dissipation, 350 h.p.
– – – – Cavitation limit pump suction lift, 12ft.
—·—·— Cavitation limit pump suction lift, 16ft.
— – — – Cavitation limit pump suction lift, 20ft.
It is assumed that the minimum permissible pressure in the valves is 12ft of water abs.

Fig. 17—Control Valve 3. Estimated Performance of Full-Size Valves on Closed Pump Research Rig

along the length of the passage). A more interesting situation arises at the larger valve openings. Here the variation in E_2-E_x along the annular passage will be much less, as the loss in the exit section beyond the maximum plug diameter forms a greater part of the total loss. The variation in A_2^2/A_x^2 remains the same. If the values of $E_2-E_x/\frac{1}{2}V_2^2$ are of the same order as the values of A_2^2/A_x^2, which was the case with the models tested, differences in the form of the valve may cause considerable differences in the location and the magnitude of the minimum pressure. Again, the experimental results con-



Inlet section : area normal to flow A_1 ; mean velocity V_1 ; static pressure p_1.
Section x : area normal to flow A_x ; mean velocity V_x ; static pressure p_x.
Outlet section : area normal to flow A_2 ; mean velocity V_2 ; static pressure p_2.

Fig. 18—Diagrammatic View of Control Valve Type 3

firm this conclusion. The point of lowest pressure was found midway along the plug, or at the nose, on those models based on a 12 deg. taper when the valve opening was large. Models 1, 2, and 6 in which the variation of A_2^2/A_x^2 between the plug nose and maximum diameter was one half or less than that in the others, had the minimum pressure point located near the maximum diameter at the same valve openings.

The Effect of Rough Surfaces on the Performance of Valve Type 3.—The surface on all the models tested was machined to a smooth finish, and in the valves of 1in diameter both plugs and bodies were polished. The degree of finish will not necessarily be the same in the full-size valves, and they may be roughened in service by corrosion or accretions. The change in performance which may be produced should therefore be considered.

Equation (1) enables a qualitative prediction to be made of the change likely to occur. The loss coefficient at a given valve opening can be expected to be greater for a valve with rough surfaces than for one with smooth surfaces, because of the greater losses which will take place in the annular section. The loss in the section beyond the maximum diameter of the plug, which may be regarded as being for the greater part the "pressure drag" of the plug, will be affected to a much smaller extent. If both valves are to operate at the same loss coefficient, the opening will be greater in the case of the valve with rough surfaces than for smooth. Two conclusions follow : first, that the value of the "pressure drag" loss is likely to be less for the rough valve than for the smooth surfaced, because of the general decrease in velocity due to the larger opening ; secondly, that the value of A_2^2/A_x^2 at any section will be less for the rough than for the smooth-surfaced valve. The first result suggests that the value of $(E_2-E_x)/\frac{1}{2}V_2^2$ will probably decrease more rapidly as x increases for the rough than for the smooth-surfaced valve. It is thus seen from equation (1) that for any given value of $E_2/\frac{1}{2}V_2^2$ the loss coefficient, the value of $(p_2-p_x)/\frac{1}{2}\rho V_2^2$ must be less for the valve with rough than with smooth surfaces, with the single assumption that the value of ε is not very different in the two cases. The lowest local pressure in the rough-surfaced valve will therefore be greater than in the smooth one. The effect will be greater at small than at large openings, both because the relative roughness in the annular passage will be greater and because at large openings the loss beyond the maximum plug diameter makes an important contribution to the total. There may be an increase in the minimum pressure loss of the rough valve, but this is likely to be small. These conclusions apply equally to uniform roughness due to machining effects, or to possible non-uniform roughness due to corrosion or accretions, though if the plug or body contour is materially altered by these the valve performance may suffer.

Diesel-Electric Shunting Locomotives

Two designs of standard diesel-electric shunting locomotives are now being made by the Yorkshire Engine Company, Ltd., of Sheffield, for heavy industrial use. One of these locomotives has four wheels and a rating of 275 h.p., and the other six wheels and a rating of 400 h.p. Each design is fitted with a diesel engine supplied by Davey, Paxman and Co., Ltd., and electrical equipment designed and made by the British Thomson-Houston Company, Ltd.

The 275 h.p. locomotive has a rigid frame built up of steel plates and castings, and the total weight, all of which is available for adhesion, can be varied between 35 and 45 tons. A traction motor with reduction gearbox is hung on each axle. The main frame of the 400 h.p. locomotive is built up of steel plate and steel fabrication. The total weight of this locomotive, which is illustrated on this page, is 50 tons.

Roller axle bearings are fitted on the heavier locomotive, but the lighter locomotive can be fitted with either plain or roller bearings ; in each case manganese steel liners are fitted to the guides. On each locomotive Westinghouse straight air brake equipment operates through fully compensated clasp rigging, and pneumatic sand ejectors below four sand boxes are operated from the cab.

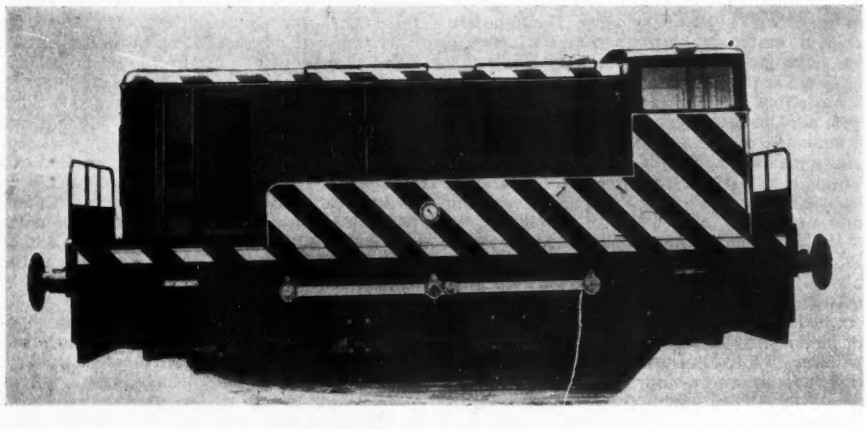
The leading particulars of the two locomotives are as follows :—

	275 h.p.	400 h.p.
Locomotive weight	37/45 tons	48/50 tons
Maximum tractive effort	26,000 lb	30,000 lb
Tractive effort at continuous rating	12,500 lb	10,700 lb
Speed at continuous rating	6·3 m.p.h.	10 m.p.h.
Total installed diesel engine rating at	1360 r.p.m.	1250 r.p.m.
Horsepower available for traction	262 h.p.	375 h.p.
Wheel arrangement	Four wheels coupled	Six wheels coupled
Wheel base	7ft	11ft
Wheel diameter	3ft 6in	3ft 8in
Gear ratio	22·85 : 1	19·75 : 1
Minimum rail clearance	7in	7in
Fuel tank capacity	175 galls.	400 galls.

Many other points of design and construction are common to the two locomotives. The power unit comprising the diesel engine, generator and radiator is mounted on a common underbed, supported by four resilient pads on the cross stretchers of the main frame. The exciter and compressor are mounted on top of the generator and are driven by vee belts from the free end of the generator. A radiator fan and auxiliary generator are also driven by vee belts from the engine. The superstructure consists of the compartment containing the power unit and switchgear. At the front end, and divided by a bulkhead, is the radiator with side louvres, through which the air is drawn in, and this air is discharged through a grille in the roof. In the cab a control desk with start and stop lever, instrument panel and gauges is mounted on the forward panel. The throttle and reverser and the brake are duplicated on each side of this desk. A hand brake is provided in the cab.

The main generator, which supplies the two traction motors, is directly coupled to the diesel engine. A load control device, which includes a hydraulically operated rheostat, regulates the field of the exciter to prevent overloading of the engine, and this ensures that full engine horsepower is available when required under all conditions of load. The system used provides continuous and smooth variation of locomotive speed and tractive effort from standstill to full engine power simply by varying the engine speed.

The single bearing main generator has the driven end of the armature spigoted on to the engine coupling. The traction motors have rolled steel frames and plate end shields. Each motor is mounted at right angles to the axle and is spigot mounted on an axle-hung double-reduction gearbox ; the drive to the road axle is by means of spiral bevel and single spur gears. A lead-acid battery is used for starting the diesel engine by motoring the main generator.



400 h.p. Diesel Electric Shunting Locomotive

Hydraulic Floor Crane

A MOBILE hydraulic floor crane with a maximum lifting capacity of 1 ton is now being made in two forms by Harvey Frost and Co., Ltd., of Bishops Stortford, Herts. One version of the crane is designed for use in garages and the other in stores and industrial establishments.

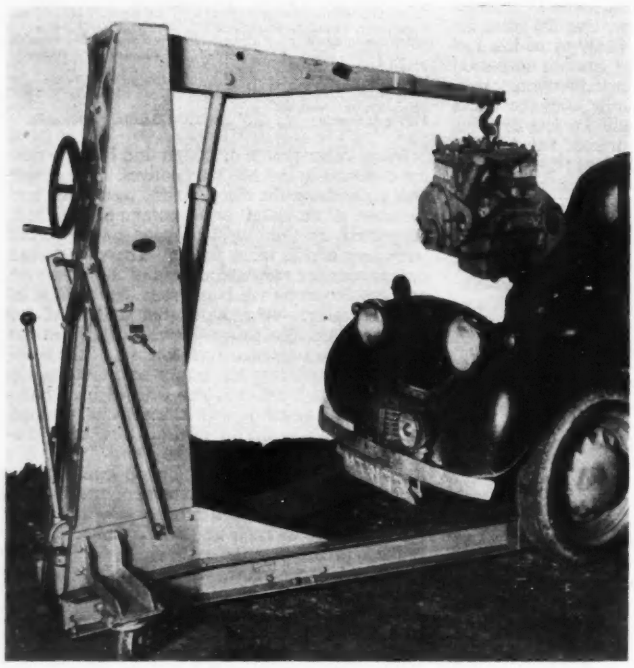
The crane, as can be seen from the photograph we reproduce below, is supported on two structural steel leg members splayed to give stability, and fitted with ball bearing castor wheels on outriggers at the rear and fixed ball bearing wheels at the front. A pair of well-braced fabricated post members are mounted on a base assembly which rigidly couples the legs together and provides a platform for a hand lever operated hydraulic pump. This pump provides the pressure fluid for the ram used to actuate the crane jib, the ram cylinder being mounted on a trunnion bracket at the lower end of the crane post and the piston being coupled to the jib.

In the garage crane the jib is supported in trunnions on a bracket which forms a sliding carriage moving in guides between the post members. This jib carriage can be moved vertically over a distance of 1ft 3in, through a heavy screw turned by means of the handwheel to be seen on the back of the post. Vertical jib adjustments can be made with the hook loaded or unloaded, and this range of movement can be used to good advantage to keep the jib horizontal when removing or replacing engines in lorries with overhanging cabs. The industrial crane is not provided with means of vertical jib adjustment, and its trunnion bracket is mounted at the head of the post.

Each jib is fitted with a telescoping end section, with pin location, which can be retracted to give a minimum overhang of 3ft 5in, or extended to give a maximum reach of just under 4ft 8in. A towing handle which is fitted can be locked back against the post well clear of the pump lever when not in use.

With the jib lowered the crane has a maximum height of 6ft 2in. With the jib carriage in the highest position and the end section extended the hook can be raised from a height of 1ft 8in above floor level to a height of 9ft 4in with a maximum load of 15 cwt. When the jib extension is retracted a load of up to 1 ton can be raised from 2ft 8in above floor level to a maximum height of 8ft 6in. With the jib carriage in its lowermost position and the end section extended the hook can be raised from 4½in above floor level to a height of 8ft, with a 15 cwt load. When the jib extension is retracted the hook can be raised from 1ft 4in to a height of 7ft 2in with a load of 1 ton.

On the industrial crane, with the fixed centre jib, the hook heights with the jib extended and retracted are from 1ft 8in to 9ft 4in and 2ft 8in to 8ft 6in respectively.



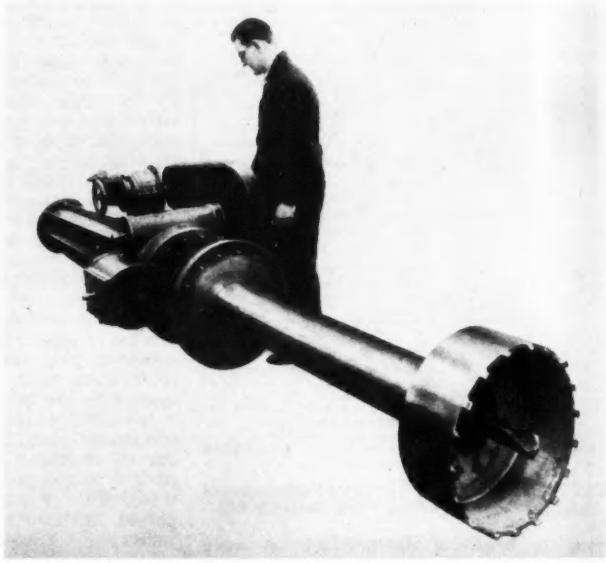
Mobile Hydraulic Floor Crane

Pipeline Drilling Machine

DURING the past few years a number of under-pressure drilling machines for high-pressure oil pipelines have been built to special order by E. Pass and Co., Ltd., of Denton, Lancs, for oil companies. These machines are used in the making of branch connections to pipelines without taking the lines out of service. In this class of work a branch connection is either welded or attached by special clip connections to the pipeline and fitted with a "fullway" valve. The drilling machine is then bolted to the flange above the valve and its trepanning cutter lowered through the valve and branch to cut out a section of the pipe. The cutter and trepanned section is then withdrawn and when the valve has been closed the drill is removed and the branch pipe coupled up to the flange of the valve. In this way the branch connection is made without taking the pipeline out of service and with a very small loss of oil.

A standard range of under-pressure drilling machines suitable for use on pipelines under pressures up to 600 lb per square inch is now being made by E. Pass and Co., Ltd., and one of these machines is shown in the illustration above. This standard machine is designed for cutting holes from 8in to 20in diameter in steel pipelines, and it has a traverse of 72in to enable tappings to be made through 20in oil valves and welded flanged necks. It is operated by a 6 h.p. air motor and all its gears are completely enclosed. By means of clutches automatic cutter feed can be engaged or the spindle traversed rapidly to feed the cutter up to the pipe. Centre drills and pilots fitted with plungers engage the section cut out and withdraw it with the cutter at the end of the operation. A rod is provided to measure the length of traverse whilst the machine is in operation.

For use in connection with high-pressure pipelines at up to 1500 lb per square inch an open design of machine has been developed. This design of machine allows high-pressure oil or vapour to escape in the event of the shaft seal failing, and eliminates danger of pressure building up in the casing, as would be the case with an enclosed machine. Both designs of drilling machine can be provided with either flanged or screwed adapters to suit the kind of connection required.



Pipeline Drilling Machine

Slide Rule for Calculating Steel Quantities

A SLIDE rule for calculating the weights of steel sections and plates is now being made by Miles Druce and Co., Ltd., Horn Lane, Acton, London, W.3. The rule is 20in in length and the basic scale at the top of the rule, the "A" scale, of weight in pounds per foot, can be used for computations with any material. There are two slides, and when using the "A" scale, the cursor attached to the upper slider is first set against the required "A" scale value of pounds per foot. The lower side of this slider—the "H" scale, is calibrated for length (feet) and the contiguous "J" scale on the lower slider in "number of bars" (or pieces of sheet or of whatever section is concerned). The "J" scale is then set by moving the lower slider until the appropriate "number of bars" reading coincides with the "length of bar" reading on the "H" scale. Two cursors, both fixed to the lower slider, then give the total weight of material in tons or in pounds, respectively, as required, on the "K" or "L" scales at the bottom of the rule.

The scales "B" to "G" inclusive, can be used instead of the "A" scale to give weights of particular sections or shapes. For instance, round or square bar size is shown on the "B" scale, with a line on the cursor for "round" and one for "square"; to find the weight of round bar, for instance, the first setting is the diameter on the "B" scale (or the "C" scale if it is in millimetres) and it is not necessary to know the weight per foot. The "D" scale, on the upper stock, and the contiguous "E" scale on the upper slider, are used for width and thickness of flats, and at the right-hand side of the rule, the "E" and "F" scales are similarly placed and are used for angles or tees, so that it is not necessary to know the weight per foot for any of these sections.

The rule may also be used to find the number of bars per ton of any given section, or the number of bars to make up a given length, or for other similar computations. Its accuracy is to three significant figures, the third figure being interpolated as on a 10in slide rule. Care must be taken not to move the first slider when setting the second one to it, but if this point is borne in mind, the rule appears to give a convenient facility of computation.

Industrial and Labour Notes

F.B.I. Representations on the Budget

The Federation of British Industries has issued the text of the representations which it has made to the Chancellor of the Exchequer on the subject of the Budget. The F.B.I. says that the current financial year has seen a marked increase in economic activity, though it considers that improvement is very uneven. Enough has not yet been done to increase exports, the volume of which barely surpasses the figures for the previous year, though world trade as a whole has increased. Competition is growing more intense, the F.B.I. comments, and it is essential that this country's resources should be used more effectively, productivity increased and costs reduced.

If costs are to be brought down, the F.B.I. suggests, more incentive and more investment in industry are essential. This country's chief competitors—the U.S.A., Germany and Japan—are all devoting to the latter a higher percentage of the national income than is the United Kingdom. Though there was less pressure on industry's resources in 1952 than in the earlier post-war years, it still remains true that industry will need to undertake extensive capital expenditure to maintain and expand its efficiency in the face of competition. It is the Federation's hope that in 1954, as in 1953, the Chancellor will aim at only a moderate surplus and that a determined attempt will be made to reduce the total of Government expenditure. The Federation says that the demands made by Government on the national resources are still far too high and that even when all practicable economies are made there will still be a heavy load of taxation to be borne, as would become only too apparent on the slightest recession in business. It is essential, the statement urges, that this should be levied in such a way as to effect the least blunting of incentive and to create the least hindrance to a development of industrial activity that will increase the national income, and thus spread the weight of the burden. The F.B.I. thinks that the procedure adopted last year was the best method to achieve the maximum incentive in return for the sacrifice of revenue, namely, to give a substantial aggregate relief fairly balanced between direct and indirect taxes.

Capital Expenditure in Northern Ireland

The Northern Ireland Minister of Commerce stated last week that legislation was to be introduced which would enable his Ministry to make grants generally towards capital expenditure by industry in Northern Ireland on the purchase of plant and machinery and on the construction of new buildings. This arrangement, he stated, would be for a limited period.

The Minister explained that the Government of Northern Ireland had reviewed the existing methods of assistance, in particular the Re-equipment of Industry Acts, under which the closing date for applications was December 31st last. It was not proposed to extend the time limits under these Acts, as their provisions were based on the idea of comprehensive schemes of re-equipment and modernisation to be carried out within a limited period. On the other hand, the Minister continued, the Government recognised that, in present circumstances, financial assistance might well be necessary to encourage industry to invest in new plant, machinery and buildings up to the levels which were essential either for increasing productivity or for expanding production and employment.

The Minister went on to say that the existing powers, under the Industries Development Acts, to assist the expansion of employment by grants to industry would be continued. He also stated that he had enlisted the aid of a small committee of accountants to advise him on accounting practice in industry so that he could consider how the proposals could best be co-ordinated with existing practice. It was the Government's intention, if the necessary expenditure was sanctioned, to make annual grants, covering a period of three years in all, and that in each case these grants would be related to expenditure during the firm's accounting year, starting with the first accounting year after December 31, 1953.

Education and Industry

At a recent meeting of the London and South Eastern Regional Board for Industry, there was presented a survey on the educational standards of entrants into industry from secondary modern schools. The survey was based on the views of a representative selection of manufacturing firms within the region. It showed that 56 per cent of the employers were dissatisfied with the educational standards of the present secondary modern school system, that 29 per cent were satisfied, and that 15 per cent were unable to give a definite opinion.

Among the adverse comments were that many school leavers were quite unfit to begin a course of technical training; that some were unable to spell five-letter words, and that office juniors had an "embarrassing lack of knowledge of geography and arithmetic." The chairman, Sir John Buchanan, said that it was the Board's business to point out that a large number of industrial employers were not satisfied with the educational standards of boys being recruited from the secondary modern schools. The Board decided that copies of the survey should be sent to the education authorities in the region.

Economic Development of British Guiana

On Monday last, the Secretary of State for the Colonies, Mr. Oliver Lyttelton, gave some information to the House of Commons concerning plans for further economic developments in British Guiana. He said that it could not yet be estimated exactly what the development plans for the Colony over the next five years would involve, but the cost was not likely to be less than £15,000,000. Detailed proposals for the next two years costing about £9,000,000, had, however, been produced. They included, first, rather more than £3,000,000 for transport, communications and other public works, to reconstruct and expand roads, railways, ports and telephones, and, secondly, over £2,500,000 for agriculture and forestry, to carry out research, major drainage and irrigation schemes and land settlement for small farmers. In addition, £2,500,000 would be expended on social development including a housing programme, and £1,000,000 on agricultural and industrial credits which would be administered by a credit corporation.

Mr. Lyttelton went on to say that it was an ambitious programme, and that there would be shortages—of materials, skilled staff and artisans—which might slow down the rate at which the programme could be carried out. But, he added, the Government was determined that as much as was practicable should be done as soon as possible, and that worthwhile development should not be held up for lack of money. As a first step, therefore, the Government had decided to make available a further grant of £3,125,000 from Colonial development and welfare funds, and to provide facilities for up to £3,417,000 extra loans to be raised as required in London.

British Iron and Steel Industry

Some comments on the British iron and steel industry's position were made last week, at the annual meeting of Colvilles, Ltd., by Sir John Craig, chairman and managing director of the company. Sir John said that one outstanding development during the past year had been the discovery of great resources of iron ore in various parts of the world. Large resources had been discovered in Africa, and, with other steel makers, the company was developing iron ore mines in that country. It was evident that there was an abundance of iron ore available and the question of transport had been duly considered. In that field, too, British steel makers had co-operated by completing agreements with ship owners for the building of ships specifically for the carrying of iron ore.

Sir John also made some reference to the European Coal and Steel Community which, he said, was now beginning to function actively in the affairs of the Continental steel makers. It was now facing problems within its own organisation and the shape of the Community's future development, Sir John thought, would depend on how those present problems were solved. The question of the relationship between the British steel industry and the Schuman Plan countries, Sir John said, was one of national policy. In the past, relations with the Continental steel makers had been cordial, and were of benefit not only to the British steel industry, but also to the consumers of steel in this country.

Iron and Steel Production

Figures relating to British iron and steel production in January, which have been published this week by the Iron and Steel Board, show that the output of steel ingots and castings averaged 360,300 tons a week. The Board says that this is the highest figure ever recorded for January, and indicates that the industry started the year at an annual production rate of 18,737,000 tons, compared with an annual rate of 18,009,000 tons in January, 1953. Pig iron production last month, at 229,600 tons a week, was the highest to be recorded. It represented an annual output rate of 11,941,000 tons, against 11,121,000 tons a year previously.

Employment and Unemployment

The Ministry of Labour's latest report on the employment situation states that in December the working population in Great Britain declined by 100,000, most of the decrease being accounted for by the fact that there were fewer women in employment. At the end of the month, the working population numbered 23,474,000 (15,920,000 men and 7,554,000 women).

The number of people in civil employment in December was 22,288,000, which was 112,000 fewer than in November. Of the December total, 3,988,000 were engaged in the country's basic industries. Although in these industries there was a net loss of 14,000 during December, there was an addition of 1000 to the number employed in coal mining, the total at the end of the month being 710,000, compared with 720,000 at the end of 1952. There was also a decline in December in the number employed in the manufacturing industries, the total at the end of the month being 8,932,300. In the "engineering, metal goods and precision instruments" group, 2,602,000 people were engaged, which indicated a drop of 1000 during the month, but in vehicle manufacturing employment increased by 4000 to 1,156,000.

Unemployment figures given in the Ministry's report show that on January 11th there were 372,856 people registered as out of work. This was 51,063 more than a month earlier.

Managing the Small Firm

Last year, the British Institute of Management, in conjunction with the National Union of Manufacturers and the Institute of Industrial Administration, held a conference to discuss management problems affecting smaller firms. A similar conference, supported by the three original bodies and also by the Federation of British Industries, is being arranged for this year, and it will be held on Friday, Saturday and Sunday, March 5th, 6th and 7th, at Ashorne Hill, Leamington Spa. The general theme for this conference is "Managing the Small Firm," and the programme is designed to cover a variety of present-day management problems. Among the subjects for discussion are financial control, work study, standardised costing, export marketing, and problems of growth.

Full details of the conference and application forms can be obtained from the British Institute of Management (Room 029), 8, Hill Street, London, W.1.

Notes and Memoranda

Air and Water

MARINE REFRIGERATION.—We have received from G. and J. Weir, Ltd., Cathcart, Glasgow, S.4, a copy of a brochure entitled "Weir Marine Refrigeration," which briefly describes the range of equipment manufactured by the company, and includes photographs of various ship installations.

MODERNISED TROOPSHIP.—The troopship "Devonshire," which was built for the Bibby Line, Ltd., by the Fairfield Shipbuilding and Engineering Company, Ltd., in 1939, is now back in service after completing an extensive refit by her builders, in the course of which the accommodation has been brought up to conform with modern standards.

LAUNCH OF DREDGER.—The twin-screw grab hopper dredger "Lennox II," building for Clyde Navigation Trustees, was launched last week from the yard of Ferguson Brothers (Port Glasgow), Ltd. The vessel has a hopper capacity of 800 tons, two cranes capable of dredging to a depth of 50ft, and is propelled by twin triple-expansion engines.

SPECIAL LLOYD'S PANEL.—We are informed by Lloyd's Register of Shipping that the general committee has set up a special panel to consider problems arising in modern cargo ships of certain design and construction. The panel will be under the chairmanship of Sir W. Guy Ropner and consists of shipowners and shipbuilders and representatives from foreign shipbuilding countries.

AMOS AYRE LECTURE.—The Council has welcomed the proposal of the Shipbuilding Conference that the Institution of Naval Architects should found an "Amos Ayre Lecture" in memory of the late Sir Amos L. Ayre, K.B.E., D.Sc. The lecture is to be given at intervals of three years, and the Shipbuilding Conference has offered a fifty guinea honorarium and "Amos Ayre Medal" to be awarded to the lecturer who will be nominated by the Council.

"BRITANNIA" ACCIDENT.—On February 4th the prototype Bristol "Britannia" airliner developed a fire in an engine bay and had to be forced landed. The company's chief test pilot, Mr. Pegg, was at the controls. He had originally hoped to make an emergency landing at Filton, but was subsequently obliged to pancake the machine on some mud flats, the fire having persisted. One of the fourteen occupants was slightly injured. The machine was not extensively damaged and it is expected that parts of it may be usefully salvaged. The engine which caused the fire is being examined at the company's works at Filton.

WATER TURBINE PLANT GEAR UNIT.—Among recent orders for water turbine plant completed by David Brown and Sons (Huddersfield), Ltd., was a combined helical and bevel increasing gear unit for the North of Scotland Hydro-Electric Board's scheme at Mullardoch Tunnel, Inverneshire. This gear unit is designed to transmit 3600 h.p. continuously at 208/755 r.p.m. and it has a vertical input shaft and horizontal output shaft. A single helical gear on the input shaft, which is located on a roller bearing above and heavy Michel thrust bearing below, is of 32in centre and 32in face width. The drive is transmitted through an intermediate vertical shaft and spiral bevel gears, each of which has an 8in face. These bevel gears are arranged at 27in cone distances. All of the gears are of alloy steel, and the unit, which has a forced lubrication system, is enclosed in a fabricated case.

THE "COMET II."—The first production "Comet" airliner to be fitted with the Rolls-Royce "Avon" engine has now returned from Africa, where it has been undergoing tropical acceptance trials. It had left Hatfield on Friday, January 22nd, and flew non-stop to Khartoum, a distance of 3080 miles, in the record time of 6 hours 23 minutes, at an average speed of over 480 m.p.h. On this flight the "Comet" was carrying a payload of 10,500 lb., equivalent to forty-four passengers and luggage, and on landing the fuel remaining in the tanks was sufficient for a 400-mile diversion from sea level and half an hour's circling at the alternative destination. On the following Thursday, January 28th, carrying the same payload, it flew on to Johannesburg, 2913 miles, in 6 hours 51 minutes; it had then flown a quarter way round the globe in two hops at about double to-day's airline speed. This mark of aircraft known as the Series II, has a practical working stage length of about 2200 miles with a capacity payload of 13,500 lb when recognising full airline fuel reserves. Air France has now ordered six of this series and delivery is expected to begin early next year.

Miscellanea

REFINERY THROUGHPUT.—During 1953 the British oil refineries of the Anglo-Iranian Oil Company, Ltd., had a throughput of about 9,100,000 tons, compared with 6,600,000 tons in 1952, and at the shipping terminals a total of 2557 oil tankers were handled.

REACTION RATES IN METALLIC SYSTEMS.—A two-day post-graduate course on "Reaction Rates in Metallic Systems" is to be held at Liverpool University on March 23rd and 24th. The course will consist of eight lectures by Dr. W. S. Owen, lecturer in metallurgy at the University.

OBITUARY.—We have learned with regret of the death of Mr. N. H. Miller, A.M.I.E.E., assistant liaison officer of British Insulated Callender's Cables, Ltd., which occurred on January 29th, at the age of sixty-one. We record also with regret the death, on January 22nd, of Mr. M. W. Ronayne, manager of the zinc and ironwork departments of G. A. Harvey and Co. (London), Ltd., Greenwich, S.E.7.

TRENDS OF PUBLIC SERVICE VEHICLE DESIGN.—An article under this heading appeared in our issue of January 22nd. It was indicated that it was "Contributed." That indication was in error. The article, as in fact its wording suggests, was in reality a summary of a paper presented recently by Mr. Durrant, Chief Mechanical Engineer (Road Services), London Transport, to the International Union of Public Transport at Madrid. Our apologies are due to Mr. Durrant for an editorial error.

APPRENTICESHIP HANDBOOK.—We have received a copy of an illustrated booklet giving particulars of the graduate and student apprenticeship schemes of the Brush Electrical Engineering Company, Ltd., Loughborough. This booklet has been designed specially for those leaving school or college and who are consequently deciding upon their future career. The information given covers not only details of the training schemes available, but also interesting particulars of the company's history and development.

BRITISH COUNCIL COURSES.—Among the lecture courses, for overseas specialists, which are being arranged this year by the British Council, one will cover agricultural engineering and another soil mechanics and foundation engineering. The agricultural engineering course will be held from May 30th to June 15th at the National Institute of Agricultural Engineering, Wrest Park, Silsoe, Beds, and the soil mechanics course is to be conducted in and around London. Altogether, the British Council is organising this year twenty-four courses on a variety of subjects.

THE DEVELOPMENT OF GARRINGTONS, LTD.—Last week there was shown in London for the first time a new film entitled "They've Come a Long Way," in which the history and development of Garringtons, Ltd., is graphically described. This well-known firm of steel forgers originated in a blacksmith's shop opened in 1837 near Darlaston by John Garrington. In an interesting and entertaining way the film describes the growth of the firm from these small beginnings to its present production capacity of some 70,000 tons of forgings a year. Work is shown in progress in the firm's new press forge, which is some 620ft long by 90ft wide, and we noted from the commentary which accompanies the film that a large new shop, which will considerably increase production, is now being built.

TABULAR SUMMARY OF CIVIL ENGINEERING CONTRACTS.—One of the major civil engineering works of which details were given in the *Tabular Summary of Civil Engineering Contracts* which was published as a supplement to THE ENGINEER of January 29th last, is the Manchester Ship Canal Company's oil dock at Eastham (the Queen Elizabeth II dock). An error was made in the entry for the oil dock; two major contracts were entered, one for the entrance dock and lock and one for the sliding caissons. There is, in fact, a third contract, namely, for deepening and dredging the entrance channel to the dock. The contractor for this work is the Westminster Dredging Company, Ltd., and the total cost of the dock of £5,750,000 entered in the *Tabular Summary* includes all three contracts.

DOW PRIZE COMPETITION.—In memory of John Stewart Dow, the Illuminating Engineering Society is offering a prize in a competition intended to encourage collaboration between students of illuminating engineering and students in other fields in which applied lighting plays an important part. The subject for the competition is the layout, lighting, decoration and furnishing of a dining room and cocktail bar in a city hotel. Although entries from individuals are not excluded, the competition is intended primarily for students working in collaboration. The winning entry will receive a total cash award of £75 and a certificate will be presented to each member of the winning team. Full details and application forms can be obtained from the Illuminating Engineering Society, 32, Victoria Street, London, S.W.1.

GAS WELDING GOGGLES.—A new welding goggle now being made by Stratford Products Safety Service Company, Ltd., 53, Old Kent Road, London, S.E.1, is suitable for gas welding both with and without flux. This goggle is made in a single moulding of light filtration "Perspex," and is available in two models, one for use by operators who wear corrective spectacles and the other for ordinary users. The makers point out that by combining the flux requirements into a goggle and at the same time meeting the requirements for which protection against flux welding is not required, users will be able to halve their stocks of gas welding goggles. The goggles also eliminate the risk of injury arising from the issue of goggles which do not incorporate flux protection being used on a job which requires protection. Each pair of goggles weighs about 2 oz and is fitted with a strong, adjustable elastic headband.

TELEVISION INTERFERENCE FROM LANCASTER-MORECAMBE-HEYSHAM ELECTRIC TRACTION SYSTEM.—A statement has been made by British Railways, London Midland Region, about television interference from the Lancaster-Morecambe-Heysham line, on which 50 c/s traction is now employed. It is pointed out that tests have revealed that the continuous interference which has led to the complaints is due to discharges across small voids existing between conductor and insulator surfaces on the catenary supporting insulators. Such interference, it is explained, is not peculiar to railway traction, but can occur with any extra-high-voltage transmission line using pin type insulators. On a 600 yards section the insulators have been treated with conducting grease, apparently with considerable success, and this remedial measure is being applied to the remaining affected sections. Consideration is being given to the use of a special type of insulator as a more permanent cure. The slight interference due to passing of trains is not thought to be serious.

MANAGEMENT EDUCATION IN THE STEEL INDUSTRY.—Last October, the British Iron and Steel Federation held its sixth training conference. At the five sessions of this conference, papers on subjects concerned with training for management in the iron and steel industry were read and subsequently discussed by study groups. The papers, together with summaries of the findings of the study groups, have now been published in a booklet entitled *Education and Training for Management in the Iron and Steel Industry*. It may be obtained from the British Iron and Steel Federation, Steel House, Tothill Street, London, S.W.1.

ALUMINIUM ROOF COVERING.—The Aluminium Development Association, 33, Grosvenor Street, London, W.1, has issued "Applications Brochure No. 9," "Fully Supported Aluminium Roof Covering," price 2s. 6d. This brochure sets out recommendations on the installation of aluminium for fully supported roof covering and the text is divided into three main parts, namely, materials, design considerations and work on site. British standards are quoted for the various roofing materials and certain design considerations touched upon, such as durability, metallic contact and roof covering systems, before going on to describe work on site. In this section, which is well illustrated, the technique of laying aluminium covering is discussed in some detail and it is followed by some information upon allowances and tolerances and also an appendix devoted to the definition of the terms used.

ELECTRONICS COURSE AT HARWELL.—The Atomic Energy Research Establishment is to hold its eighth specialised course on the design, use and maintenance of electronic instruments used in nuclear physics, radiochemistry and in work with radio-isotopes at the Isotope School, Harwell, from Monday to Friday, April 5th to 9th. The course, which is limited to twelve, will include lectures and practical work concerned with counters, d.c. and pulse amplifiers, coincidence units, scalers and ratemeters, and the lecturers and demonstrators will be specialists from the Atomic Energy Research Establishment. The Isotope School is outside the security fence and the subjects will be entirely unclassified. The course is open to physicists and electronic engineers holding a degree or equivalent qualification, and application forms can be obtained from the Electronics Division, A.E.R.E., Harwell, near Didcot, Berks. They must be returned by March 26th. The fee for the course is twelve guineas, and living accommodation can be arranged locally at a charge of approximately five guineas.

TRAINING SCHEME FOR CHEMICAL ENGINEERS.—A four-week intensive "Practice School in Chemical Engineering" is to be held at the Royal Ordnance Factory, Bridgwater, Somerset, during the coming summer. The Ministry of Supply is setting up the school as a contribution to the training of chemical engineers in Britain. No fee will be charged for the course and students will receive an allowance of £4 2s. 6d. per week while the school lasts, with free travel to and from their homes. The school will be open to honours students in their final university year. During their stay at Bridgwater they will study problems relating to chemical plant under the guidance of Mr. E. S. Sellers, of the Department of Chemical Engineering, University of Cambridge. They will also meet technical staff from the factory for group discussions. Students will be accommodated in a hostel near the factory at a cost of about £2 15s. per week. The course will be limited to twelve students, who will be selected by competitive interview. Entry will be limited to British subjects. Provisional dates for the course are from August 16th to September 13th next, and the Ministry says that if the school is successful this year, it may be continued as an annual event. Application forms are obtainable from the Director of Ordnance Factories (Administration and Finance), Room 88, Ministry of Supply, Leysdown Road, Mottingham, London, S.E.9. They must be returned before March 31st.

Personal and Business

MR. B. R. CARTER has been appointed a director of B. and F. Carter and Co., Ltd., Albion Works, Bolton.

BRUCE PEEBLES AND CO., LTD., states that its London office is now at 54, Victoria Street, S.W.1 (telephone, Tate Gallery 3551).

THE NATIONAL COAL BOARD announces the appointment of Mr. R. W. Parker as deputy chairman of the North-Western Division.

MR. E. J. LARKIN, A.M.I.Mech.E., has been appointed assistant mechanical and electrical engineer Derby, in the London Midland Region of British Railways.

WILLIAMS AND WOMERSLEY, LTD., Wakefield, states that the address of its South Wales agency is now "Great Glen," 9, Neville Road, Bridgend, Glamorgan (telephone, Bridgend 1174).

RICHARD LLOYD, LTD., Oliver Street, Birmingham, states that the Garage and Engineering Supplies, Ltd., 78, Great Victoria Street, Belfast, has been appointed agent in Northern Ireland for "Galtona-O.K." cutting tools.

THE CAPE ASBESTOS COMPANY, LTD., states that Mr. A. A. Cross has been appointed plant manager at the Harts Lane factory, Barking, Essex. He succeeds Mr. T. C. Hale who has been appointed technical director of the company.

BRITISH RAILWAYS announce the following appointments in the London Midland Region:—Mr. E. S. Hunt, chief regional manager, Euston; Mr. S. T. Clayton, motive power superintendent, Euston; Mr. B. Adkinson, assistant motive power superintendent, Euston.

British Patent Specifications

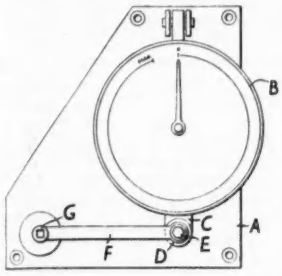
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

TOOLS AND WORKSHOP APPLIANCES

701,907. August 21, 1950.—TORQUE-INDICATING APPARATUS, Acratork Engineering Company, Ltd., Gory's Buildings, Cardiff. (*Inventors: Frank Leslie Keen and Ivor John Thomas.*)

The invention relates to apparatus for indicating torque for use with torque spanners, such as described in Specification No. 625,477. As illustrated in the drawing, it comprises a baseboard suitable for fixing to a wall. The board *A* supports a dial spring balance *B*, scaled in pound divisions. The movable spring-loaded suspension member *C* of the balance has



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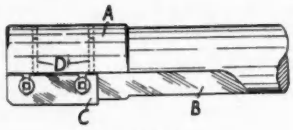
pivotally connected to it by an eye socket *D* and retaining bolt *E*, one end of a lever arm *F* arranged horizontally below and to one side of the balance. The other end of the lever arm has a pivot mounted on the baseboard, and a spanner socket *G*, coaxial with the pivot, is provided for engagement with a torque spanner or member under test. When the torque spanner is applied to the socket *G* of the lever and moved in a clockwise direction, the movement simultaneously causes the lever arm *F* to pivot downwardly to extend the spring of the balance *B* by a related movement of the other end of the lever arm, thereby giving an indication on the scale of the spring balance. If the length of the lever arm *F* between pivotal points is exactly 1ft, and provided the scale of the balance is in pounds the point where the torque spanner breaks down is given in foot-pounds.—*January* 6, 1954.

702,110. April 16, 1952.—REAMERS, Edibrac, Ltd., Centurion Works, Hartington Road, Broadheath, Cheshire, and Stanley Waite, of the company's address.

Referring to the drawing, the pilot part of the reamer *A* is cut away or recessed at *B* at the side at which the bit or blade *C* is secured. The rear-



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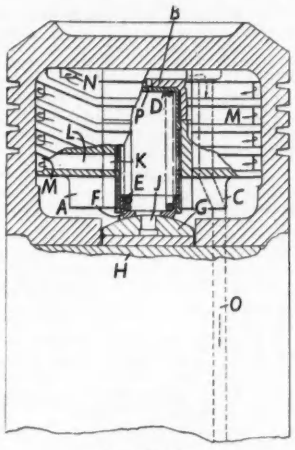
side or edge of the blade rests upon screws *D* in the pilot, which serve to adjust the position of the blade for bore dimensions and to adjust the angle of the cutting edge. Slots in the blade allow for such adjustment. The surface of the pilot is hard chromium-plated to maintain its dimensions over long periods and ensure accuracy.—*January* 6, 1954.

INTERNAL COMBUSTION ENGINES

702,002. June 27, 1951.—OIL COOLED PISTONS, Crossley Brothers, Ltd., Openshaw, Manchester, 11, and Herbert Desmond Carter, of the company's address.

The invention is concerned particularly with the oil cooling of the piston ring grooves and piston crown. Three main parts *A*, *B* and *C* are inserted in a piston to provide for the desired circulation of the oil from the engine main lubricating system in order to cool the piston wall and crown. The parts *A* and *C* are first passed up into the piston between the gudgeon pin bosses and moved laterally apart above them. Then the centre piece *B* is passed up into the piston and the parts *A*, *B* and *C* are secured together. The centre part *B* and the lower sections are secured to the piston crown by set screws. A cylinder or thimble *D* to house a compression coil spring *E* is then inserted into the hollow centre of the piece *B*. Then the spring and a ring *F* which bears upon and is shaped to conform to the end of the engine connecting-rod *G* are placed in position after which the gudgeon pin *H* and connecting-rod are assembled in the piston. The assembled components *A*, *B* and *C* make contact with the underside of the piston crown and with the wall behind the grooves. Oil from the main lubricating system of the engine is forced under pressure up the connecting-rod, through the hole *J* into the thimble *D*, through holes



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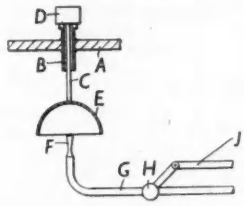
K into a passage *L* which leads to the helical peripheral groove *M* around the assembled components and so to the spiral groove *N* in the top. Finally, the oil passes down the hole through the part *C* and to a pipe which returns it to the engine crank case. Modified constructions are also shown in the specification. There is a hole *P* in the top of the thimble and in the top of the part *B* to allow air in the system to pass out of the thimble under the pressure of the oil. The assembled components constitute a secure and shakeproof fixture within a piston, none of which is subjected to stress so far as the piston gas load is concerned.—*January* 6, 1954.

ELECTRICAL ENGINEERING

697,359. July 4, 1951.—ELECTRICAL PRECIPITATION APPARATUS, Whessoe, Ltd., Darlington; and William Elyott Putnam, 26, Beechwood Avenue, Darlington.

The invention relates to electrical precipitation apparatus and has reference to means for rapping or vibrating the electrodes in order to dislodge matter deposited upon them. As shown in the drawing, a framework *A* from which the discharge electrodes (not shown) are suspended carries a vertical sleeve *B*, through which there slides a rod *C* carrying a weight or hammer block *D* at its upper end and an inverted



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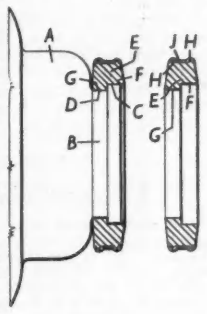
cup *E* at its lower end. Below the cup is an upward-directed jet nozzle *F*, which is connected through a pipe *G* provided with a control valve *H* to a source of compressed air. When the control valve is opened the jet of air impinging on the cup lifts the rod with its hammer block, when the valve is again closed the hammer block falls and strikes a blow against the upper end of the sleeve *B*, thus vibrating the discharge electrodes. A lever system *J* is connected to the valve *H* for opening and closing it; the lever system may be operated manually or by automatic means at any required intervals of time. By spacing the nozzle *F* at the end of the earthed pipe at a sufficient distance from the high-tension cup *E* all danger of flashover between these parts can be avoided without the use of any insulating materials. Alternatively, the nozzle and end portion of the pipe may be made of insulating material. A modified arrangement is also described in the specification.—*September* 23, 1953.

696,104. June, 4, 1951.—MOUNTING OF ELECTRIC MOTORS, General Motors Corporation, Grand Boulevard, Detroit, Michigan, U.S.A. (Assignees of Ralph K. Shewmon, 1118, Oakdale Drive, Dayton, Ohio, U.S.A.).

The invention relates to improvements in mountings for electric motors, dynamos and the like. The drawing shows an electric motor casing having a resilient mounting ring, according to the invention, on a grooved hub of the casing. The casing *A* of the electric machine has a cylindrical extension or hub *B* which is coaxial with the rotor and which has an outer peripheral groove forming two annular surfaces *C* and *D*, the annular surface *C* being at the outer end of the hub and the larger in diameter. The resilient mounting ring *E* is made of synthetic rubber, capable of withstanding the destructive effects of oil or grease. It is as thick axially as the hub is long and has its inner surface formed with stepped portions *F* and *G*. The outer peripheral surface of ring *E* may be grooved or, as shown in the drawing, annular ridges *H* may be formed on it. A metal ring *J*, grooved to conform to the ridged outer contour of the resilient ring, encircles and grips the ring *E*. When assembled on each end of an electric machine, rings *J* fit and rest in uprights in a supporting cradle.—*August* 26, 1953.

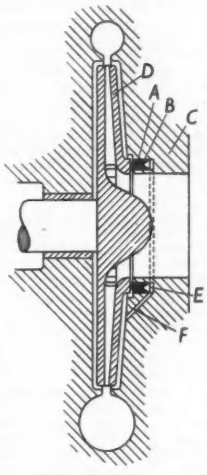


No. 696,104

SHAFT SEALING DEVICES

702,105. March 18, 1952.—SEALING DEVICE FOR RELATIVELY MOVING PARTS, Svenska Flygmotor Aktiebolaget, Trollhättan, Sweden.

The invention is a packing for making a fluid-tight joint in axial direction between elements, such as a shaft and a fixed housing surrounding it. The packing consists of two parts *A* and *B*, one of which, *B*, is made of elastically deformable material and is so shaped that it tightens against one of the two relatively moving elements, which, in this case, are the pump housing *C* and the pump rotor *D*. The other part *A* of the packing is made of a substantially rigid antifriction material, such as graphite, and is arranged to press against the other of the two movable elements, in this case the pump wheel *D*, under the action of the part *B*. The two packing parts are located in an annular groove *E* substantially coaxial with the pump shaft. This groove is connected, near its bottom, by a channel *F* to the space between the pump rotor and the pump housing. As the pressure in this space increases toward the periphery of the rotor, a desired pressure of fluid in the groove *E* can be obtained by suitably choosing the radial position of the end of the channel. As the part *B* of the packing is deformable it will yield to the pressure of the fluid in the groove and will press the part *A* against the adjacent surface of the rotor *D*. As shown, the part *B* is of substantially "U"-shaped cross-section, and the shanks of the "U" are pressed outward by fluid pressure against the opposite sides of the groove *E* while the junction of the shanks abuts on the part *A*, and may be attached to it so that the two parts cannot rotate relatively to each other.—*January* 6, 1954.



No. 702,105

METALLURGY

702,101. December 27, 1951.—HEAT TREATMENT OF HARD METAL CARBIDES WITH AN AUXILIARY BINDING METAL FOR THE PRODUCTION OF A HARD METAL OF INCREASED TOUGHNESS, Gebr. Böhler and Co. Aktiengesellschaft, Elisabethstrasse 14, Vienna 1, Austria.

The specification describes a process for the heat treatment of hard metal carbides with an auxiliary binding metal for the production of sintered hard metals having increased toughness. The binding medium consists of one or more metals of the iron group and the process is characterised by a heat treatment following the usual sintering operation which is intended to precipitate the hard components dissolved in the binder, the heat treatment comprising an annealing at temperatures between 600 deg. and 1000 deg. Cent., preferably between 800 deg. and 900 deg. Cent., for two to ten hours.

Increased toughness is achieved in a known way by suitable grading of the grain size of the hard component. The application of the process to hard metals comprises a fine portion of hard component having a grain size of 0·5 to 2μ and a coarse portion of a grain size of 2 to 5μ the respective amounts of these two grain sizes being selected within the ratios of 1 : 3 to 3 : 1. Sintered hard metals which have been produced by the process with an auxiliary metal consisting of cobalt are characterised by the fact that the specific magnetisation of its binding medium consisting of cobalt, exceeds 140 c.g.s. units.—*January* 6, 1954.

Launches and Trial Trips

SWIFTPOOL, cargo liner; built by the Caledon Shipbuilding and Engineering Company, Ltd., for Sir R. Ropner and Co. (Management), Ltd.; length overall 485ft, breadth moulded 63ft 3in, depth to shelter deck 40ft 9in; six cargo holds, eighteen derricks, twelve passengers, electric deck machinery, three 200kW diesel-driven generators; Stephen-Doxford oil engine, six cylinders, 7000 b.h.p. Launch, January 19th.

RAMBLER ROSE, cargo ship; built by John Lewis and Sons, Ltd., for Hughes Holden Shipping, Ltd.; length between perpendiculars 255ft, breadth moulded 35ft 6in, depth moulded to upper deck 15ft 9in, deadweight 1600 tons, three holds; two 80kW diesel-driven generators; Lewis-Doxford oil engine, three cylinders, 440mm diameter by 1400mm combined stroke, 1100 b.h.p. at 145 r.p.m. Launch, January 21st.

BRITISH MERCHANT, oil tanker; built by Swan, Hunter and Wigham Richardson, Ltd., Wallsend yard, for the British Tanker Company, Ltd.; length between perpendiculars 630ft, breadth moulded 85ft 6in, depth moulded 46ft 8in, deadweight 31,750 tons on 35ft draught, service speed 14¼ knots; thirty cargo oil tanks, one cargo pump room, three 850 tons per hour turbine-driven pumps, steam deck machinery; a single set of double-reduction geared turbines by the Wallsend Slipway and Engineering Company, Ltd., 13,750 s.h.p. at 116 r.p.m. of the propeller, service power 12,500 s.h.p.; two Babcock and Wilcox integral furnace boilers supply steam at 450 lb per square inch and 750 deg. Fah.; two 600kW turbine-driven alternators, two 50kW motor-driven generators, one 150kW diesel-driven alternator, one 50kW steam-driven generator. Trial, January 20th.

TINTAGEL CASTLE, cargo ship; built at Belfast by Harland and Wolff, Ltd., for the Union Castle Line; length between perpendiculars 465ft, breadth moulded 65ft 6in, depth moulded to shelter deck 41ft 6in, gross tonnage 7450; twelve passengers; nine watertight compartments, five main cargo holds, derrick complement includes one of 80-ton and two of 30-ton capacity; electric deck machinery, three 250kW diesel-driven generators; Harland and Wolff two-cycle, double-acting oil engine, eight cylinders 620mm diameter by 1400mm stroke, one Cochran and one Clarkson boiler. Launch, February 4th.

PORT MONTREAL, cargo ship; built at Govan by Harland and Wolff, Ltd., for the Port Line, Ltd.; length between perpendiculars 440ft, breadth moulded 64ft, depth moulded to shelter deck 39ft 5in, gross tonnage 6400; four passengers; five cargo holds, fourteen derricks for loads up to 15 tons and one to lift 70 tons, electric deck machinery, three 300kW diesel-driven generators; Harland-B. and W. single-acting, two-cycle, opposed-piston oil engine, seven cylinders, 750mm diameter by 2000mm combined stroke, 112 r.p.m., two Cochran boilers. Trial, February 4th.

CLEMENT ADER, passenger and cargo liner; built by the Ateliers et Chantiers de la Loire for Chargeurs Réunis; length between perpendiculars 502ft, breadth moulded 64ft 4in, depth to upper deck 41ft, draught 27ft 11in, load displacement 17,500 tons, deadweight 9000 tons, designed speed 17 knots; 91 first and 52 second-class passengers, also 398 steerage; three complete decks, nine watertight compartments; two Sulzer diesel engines, eight cylinders, 720mm diameter by 1250mm stroke, 10,000 b.h.p. at 120 r.p.m., 12,000 b.h.p. at 130 r.p.m.—Trial, February.

COMPLAISANT, tug; built by the Ateliers et Chantiers de la Manche for the Société Dunkerquoise de Remorquage et de Sauvetage; length between perpendiculars 96ft 10in, breadth moulded 24ft 11in, depth 15ft 5in, mean draught 12ft 2in, draught aft 14ft 2in, speed 12 knots; Burmeister and Wain diesel engine, 1250 b.h.p. Trial, February.

Contracts

BRITISH INSULATED CALLENDER'S CABLES, Ltd., has received an order valued at over 3,000,000 dollars from the British Columbia Electric Company for the supply and installation of some 77 miles of 138,000V gas pressure type cable. This cable will be laid across the Georgia Strait for transmission of power from the mainland to Vancouver Island to provide an adequate supply for future development. The cable route, to be determined more exactly by marine surveys this spring, will be somewhere between Greater Vancouver and a point south of Nanaimo, on the island of Vancouver, where it will join the British Columbia electric system. The anticipated route includes continuous lengths of cables, each approximately 17 miles, laid under water at depths up to 600ft. Four single-core 138,000V cables will be required—three for regular use and one as a reserve and the circuit will be able to transmit approximately 112MW. The cable will be a gas pressure cable with a hollow copper conductor, pre-impregnated insulation, lead alloy sheath, special anti-corrosive protection and armouring. It will have a total weight of over 3000 tons.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases, the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Feb. 17th.—LONDON SECTION: School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, W.C.1, "Electronics in Film Making," W. D. Kemp and B. R. Greenhead, 6.30 p.m.

CLEVELAND INSTITUTION OF ENGINEERS

Mon., Feb. 15th.—Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, "The New Blast-Furnace and Ancillary Equipment at Shotton," F. Jones, 6.30 p.m.

ENGINEERS' GUILD

Tues., Feb. 23rd.—Imperial Hotel, Birmingham, "The Impact of Information on Industry," K. J. Ryder, 6.30 p.m.

INCORPORATED PLANT ENGINEERS

Mon., Feb. 15th.—MERSEYSIDE AND N. WALES BRANCH: Radiant House, Bold Street, Liverpool, "Mechanical Service Equipment in a Medium-Sized Chemical Factory," D. W. Evans, 7.15 p.m.

Tues., Feb. 16th.—KENT BRANCH: Bull Hotel, Rochester, "Steam Storage," E. G. Ritchie, 7 p.m.——S. WALES BRANCH: Mackworth Hotel, Swansea, "The Selection and Maintenance of Ball and Roller Bearings," 7.30 p.m.

Wed., Feb. 17th.—GLASGOW BRANCH: Scottish Building Centre, 425/427, Sauchiehall Street, Glasgow, C.2, "Industrial Lighting," F. H. Fielder, 7 p.m.——WESTERN BRANCH: Grand Hotel, Bristol, "The Generation of Industrial Power from Process Steam," E. G. Ritchie, 7.15 p.m.

Thurs., Feb. 18th.—BLACKBURN BRANCH: Grosvenor Hotel, Lord Street, Blackburn, "Fire Protection for Industrial Buildings," A. Jackson, 7.30 p.m.

Mon., Feb. 22nd.—W. AND E. YORKSHIRE BRANCH: The University, Leeds, "Engineering Problems at the Esholt Sewage and By-Products Works of the Bradford Corporation," W. H. Hillier, 7.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Sat., Feb. 20th.—BRISTOL AND W. OF ENGLAND BRANCH: Grand Hotel, Bristol, "Steel Foundry Process Control," S. L. Finch, 3 p.m.——E. MIDLANDS BRANCH: College of Technology and Commerce, Leicester, "Mechanical Aids in the Foundry," J. Blakiston, 6 p.m.

INSTITUTE OF FUEL

Wed., Feb. 17th.—N.W. SECTION: Grosvenor Hotel, Chester, "Underground Gasification," C. A. Masterman, 7.30 p.m.

INSTITUTE OF NAVIGATION

Fri., Feb. 19th.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "The Requirements for Marine Pilotage," L. W. Akerman and R. F. Hansford, 5 p.m.

INSTITUTE OF PETROLEUM

Mon., Feb. 22nd.—26, Portland Place, London, W.1, "Oil Production in the Nottinghamshire Oilfields," C. M. Adcock and R. K. Dickie, 5.30 p.m.

INSTITUTE OF REFRIGERATION

Tues., Feb. 16th.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, "Modern Methods of Oxygen Production," A. M. Clark, 5.30 p.m.

INSTITUTE OF TRANSPORT

Mon., Feb. 15th.—METROPOLITAN SECTION: 80, Portland Place, London, W.1, Symposium on "London Transport," F. G. Maxwell and J. B. Burnell, 5.30 p.m.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

Tues., Feb. 16th.—Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Mechanisation of Bracken Eradication," G. Henderson, 2.15 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Feb. 16th.—ORDINARY MEETING: Great George Street, Westminster, London, S.W.1, "History and Construction of the Foundations of the Asia Insurance Building, Singapore," W. J. R. Nowson, 5.30 p.m.

Wed., Feb. 17th.—MIDLANDS ASSOCIATION: Herbert Schofield Building, Loughborough College, "Railway Engineering in the Midlands, 1948–1953," C. W. King and F. Turton, 7 p.m.

Thurs., Feb. 18th.—N.W. ASSOCIATION: Engineers' Club, Albert Square, Manchester, "Plant for the Construction and Maintenance of Highways," R. R. W. Grigson, 6.30 p.m.

Tues., Feb. 23rd.—RAILWAY MEETING: Great George Street, Westminster, London, S.W.1, "Railway Civil Engineering Practice in the United States," N. J. Nicholls and I. M. Campbell, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Feb. 15th.—EDUCATION DISCUSSION CIRCLE: Savoy Place, London, S.W.1, Discussion on "The Teaching of the Subject of Insulating Materials," opened by Willis Jackson, 6 p.m.

Tues., Feb. 16th.—FARADAY LECTURE: Central Hall, Westminster, London, S.W.1, "Electro-Heat and Prosperity," O. W. Humphreys, 6 p.m.——LONDON STUDENTS' SECTION: R.E.M.E. Training Centre, Hazebrouck Barracks, Arborfield, Berks, "Development of Electrical Aids in A.A. Gunnery," D. H. A. Huddart, 6.30 p.m.——S.E. SCOTLAND SUB-CENTRE, Carlton Hotel, North Bridge, Edinburgh, Discussion on "Town Planning with Reference to the Electrical Engineer," opened by T. T. Hewitson, 7 p.m.——N. MIDLAND CENTRE: British Electricity Authority, 1, Whitehall Road, Leeds, 1, "Electricity in Farm Crop Drying," C. A. Cameron Brown and P. G. Finn-Kelcey, 6.30 p.m.

Thurs., Feb. 18th.—UTILIZATION SECTION: Savoy Place, London, W.C.2, "Electronic Motor Control," A. O. Dalton; "Arc-Quenching Circuits," B. H. Stonehouse; "A Survey of the Principles of the Contact Rectifier," D. R. Smith, 5.30 p.m

Mon., Feb. 22nd.—RADIO SECTION: Savoy Place, London, W.C.2, Discussion on "Acceptable Standards of Quality in Sound Broadcast Transmission and Reception," opened by J. K. Webb, 5.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Feb. 23rd.—39, Elmbank Crescent, Glasgow, "Steel Wire Ropes: Their Construction and Application," F. J. Hewitt, 6.45 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Feb. 12th.—GENERAL MEETING, APPLIED MECHANICS GROUP: Storey's Gate, St. James's Park, London, S.W.1, Third Report of the Pipe Flanges Research Committee, presented by A. E. Johnson, 5.30 p.m.

Mon., Feb. 15th.—SCOTTISH A.D. CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Automobile Engineering," Mr. Kemp, 7.30 p.m.

Tues., Feb. 16th.—EASTERN BRANCH: Dujon Restaurant, Bedford, Presidential Address, A. Roebuck, 7.30 p.m.——WESTERN BRANCH: Grand Hotel, Bristol, "Relaxation Methods: A Retrospect," Sir Richard Southwell, 7 p.m.

Wed., Feb. 17th.—N.W. BRANCH: Liverpool Engineering Society, 24, Dale Street, Liverpool, "High-Temperature Turbine Machinery for Marine Propulsion," T. W. F. Brown, 6 p.m.——YORKSHIRE BRANCH: Station Hotel, Hull, "Airships," Lord Ventry, 7.15 p.m.——N.E., A.D., CENTRE: The University, Leeds, "Combustion in Compression-Ignition Oil Engines," S. J. Davies, 7.30 p.m.

Thurs., Feb. 18th.—MIDLAND BRANCH: James Watt Memorial Institute, Great Charles Street, Birmingham, Annual General Meeting, "High-Temperature Turbine Machinery for Marine Propulsion," T. W. F. Brown, 6 p.m.——N.W. BRANCH: Engineers' Club, Albert Square, Manchester, "An Investigation of Fretting Corrosion," K. H. R. Wright, 6.45 p.m.

Fri., Feb. 19th.—GENERAL MEETING: Storey's Gate, St. James's Park, London, S.W.1, "Production and Design," L. H. Leedham, 5.30 p.m.

INSTITUTION OF MINING AND METALLURGY

Thurs., Feb. 18th.—Geological Society, Burlington House, Piccadilly, London, W.1, Discussion on the "Present-Day Meaning Given to the Term 'Ore,'" "Production of Asbestos in South Africa," W. E. Sinclair, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

To-day, Feb. 12th.—EASTERN COUNTIES BRANCH: Diocesan Hall, Tower Street, Ipswich, "The Structure of Production Management," M. Seaman, 7.30 p.m.——GLOUCESTER AND DISTRICT SECTION: Wheatstone Hall, Gloucester, "Some Applications of Automatic Controls in Industry," R. Parr, 7.15 p.m.——W. WALES SECTION: Central Public Library, Alexandra Road, Swansea, "Increased Productivity," H. O'Neill, 7 p.m.

Mon., Feb. 15th.—DERBY SECTION: College of Art, Green Lane, Derby, "Any Questions?" 7 p.m.——N.E. SECTION: N. of England Institute of Mining and Mechanical Engineers, Neville Hall, Newcastle upon Tyne, "Horizontal Boring," R. Hallam, 7 p.m.——STOKE-ON-TRENT SECTION: Town Hall, Hanley, Stoke-on-Trent, "Hot Press Forging," H. E. Hows, 7.30 p.m.

Tues., Feb. 16th.—HALIFAX SECTION: White Swan Hotel, Halifax, "Foundry Mechanisation and Improved Methods of Production," G. W. Nicholls, 7.15 p.m.——OXFORD SECTION: Town Hall, Oxford, "Cold Forming of Light Alloys," D. A. Barlow, 7.15 p.m.——YORKSHIRE SECTION: Hotel Metropole, Leeds, "Tracer Control of Machine Tools," J. Lund, 7 p.m.

Wed., Feb. 17th.—BIRMINGHAM SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "Developments and Applications in the Manufacture of Glass Fibres," J. B. Mitford, 7 p.m.——EDINBURGH SECTION: North British Station Hotel, Edinburgh, "Electronics in Industry," G. Horsfall, 7.30 p.m.——S. ESSEX SECTION: Ilford Bowling Club, Ilford, "High Productivity: The Key Features of American Production Management," L. J. Saunders, 7.30 p.m.——WESTERN SECTION: The College, Swindon, "Modern Methods of Measuring: Mechanical and Otherwise," R. Marriner, 7.15 p.m.

Thurs., Feb. 18th.—GLASGOW SECTION: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Spheroidal Graphite Cast Iron," A. B. Everest, 7.30 p.m.——SOUTHERN SECTION: Polygon Hotel, Southampton, "Cincinnati Hydrotel Milling Machines," S. C. Fenton, 7.15 p.m

INSTITUTION OF STRUCTURAL ENGINEERS

Wed., Feb. 17th.—YORKSHIRE BRANCH: Great Northern Hotel, Leeds, "Driving and Testing of Piles," H. D. Morgan, 6.30 p.m.

Fri., Feb. 19th.—S.W. COUNTIES BRANCH: Duke of Cornwall Hotel, Plymouth, "Structural Engineering at Abbey Works, Margam," A. V. R. Hooker, 7 p.m.

INSTITUTION OF WATER ENGINEERS

Fri., Feb. 19th.—S.E. SECTION AND LAND DRAINAGE SECTION: Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, "Some Examples of Hydraulic Scale Models," J. Allen, 2.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Feb. 12th.—ORDINARY MEETING: Townsend House, Greycoat Place, London, S.W.1, "Steam Utilisation and Heat Conservation," Leonard Clegg, 7 p.m.

Fri., Feb. 19th.—Townsend House, Greycoat Place, London, S.W.1, "The Design and Construction of Modern Gas Appliances," H. S. Walter, 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

Fri., Feb. 19th.—Engineers' Club, Albert Square, Manchester, "Sound Absorption," F. G. Ewing, 6.45 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

To-day, Feb. 12th.—Mining Institute, Newcastle upon Tyne, "First-Stage Reconstruction of Portobello Power Station, Edinburgh," T. P. Everett, 6.15 p.m.

OLD CENTRALIANS

Mon., Feb. 15th.—Chez Auguste Restaurant, 47, Frith Street, London, W.1, "Britain and the Commonwealth," Sir Clifford Heathcote-Smith, 12.45 p.m.

REINFORCED CONCRETE ASSOCIATION

Wed., Feb. 17th.—11, Upper Belgrave Street, London, S.W.1, "The Prestressed Concrete Framework for the Liverpool University Medical School," E. Shepley, 6 p.m.

ROYAL AERONAUTICAL SOCIETY

Thurs., Feb. 18th.—4, Hamilton Place, London, W.1, "Helicopter Research," F. J. O'Hara, 7 p.m.

SHEFFIELD SOCIETY OF ENGINEERS AND METALLURGISTS

Mon., Feb. 15th.—The University, St. George's Square, Sheffield, "The Future of Steel Melting," W. M. Thring, 7.30 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Thurs., Feb. 18th.—ROAD AND BUILDING MATERIALS GROUP: Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1, "The Use of Non-Ferrous Metals in Domestic Water Supply," Hector Campbell, 6 p.m.

WOMEN'S ENGINEERING SOCIETY

Wed., Feb. 17th.—LONDON BRANCH: 35, Grosvenor Place, S.W.1, "The Manufacture of Fashion Jewellery and Accessories," Miss D. Pile, 6.30 p.m.——MANCHESTER BRANCH: Visit to Taylor Brothers' Trafford Park Steel Works, 6.30 p.m.